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LITERARY AND PHILOSOPHICAL SOCIETY

OF

LIVERPOOL,

DURING THE

SIXTY-EIGHTH SESSION, 1878–79.

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ON THE SOCIETY'S ROLL AT THE CLOSE OF THE 68TH SESSION,

CORRECTED TO JUNE, 1879.

Life Members are marked with an Asterisk.

Oct. 21, 1872 Abbott, Joseph, B.A., 2, *Picton-street, Wavertree-road.*

Oct. 21, 1878 Adair, William, 81, *Clarence-street.*

March 24, 1879 Alexander, William, M.D., 102, *Bedford-street South.*

Nov. 4, 1867 Allen, John Fenwick, *Peaseley Vale, St. Helens.*

Nov. 12, 1877 Allman, G. W., *The Breck, Anfield.*

March 7, 1864 Archer, F., B.A., Trin. Col., Cantab., *Boundary Cottage, Little Crosby.*

*Nov. 28, 1858 Archer, T. C., F.R.S.E., F.R.S.S.A., Director of the Industrial Museum, *Edinburgh.*

Dec. 14, 1868 Ashe, Theop. Fielding, 9–15, *Atherton-street.*

Nov. 26, 1877 Atkins, H. Norwood, 7, *Hardy-street.*

Nov. 12, 1877 Atkinson, John, *Manchester-street.*

Jan. 11, 1864 Bagshaw, John, 87, *Church-street,* and 64, *Cressington Park.*

Nov. 18, 1876 Ball, Geo. Hy., *The Priory, St. George's Mount, New Brighton.*

April 20, 1874 Barton, Rev. John, M.A., *Vicarage, Rainhill.*

Mar. 18, 1878 Beall, Geo., F.R.G.S., 4, *Beech Mount, Kensington,* or 4, *Custom House Arcade.*

Oct. 21, 1878 Beasley, Hy. Charles, *Acrefield*, *Woolton*.
Nov. 15, 1869 Beer, Joseph B. de, *Northern Assurance Chambers*, *Tithebarn-street*.
Jan. 11, 1875 Bell, Wilson, 1, *Laburnum Villas*, *Egerton-street*, *New Brighton*.
Feb. 22, 1875 Bellew, Thomas A., *Cunard Mail Office*, 8, *Water-street*.
Nov. 15, 1875 Bellis, William, *Sunny Bank*, *Victoria Park*, *Wavertree*.
Jan. 27, 1879 Beloe, Chas. H., 16, *Falkner-street*, and *Unity Buildings*, 22*a*, *Lord-street*.
Dec. 10, 1866 Benas, Baron Louis, 5, *South Castle-street*.
Nov. 27, 1865 Biggs, Arthur Worthington, 28, *Exchange-street East*, and 11, *Percy-street*.
Feb. 6, 1872 Biggs, John H. W., 6, *Windsor-buildings*, *George-street*.
Oct. 31, 1859 Birch, Jas. (Messrs. Reiss Bros.), 12, *The Temple*.
Oct. 15, 1877 Birchall, F. W., *Westminster-road*, *Kirkdale*.
Jan. 25, 1864 Birchall, James, Governor of the Liverpool Industrial Schools, *Kirkdale*, Hon. Secretary.
March 9, 1866 Blood, William, *Chamber of Commerce*, and *Greta Mount*, 5, *Woodchurch-road*, *Birkenhead*.
Dec. 16, 1878 Bogue, Robert Lachlan, *The College*, *Shaw-street*.
Feb. 18, 1878 Bouch, John, 50, *Arnold-street*.
Nov. 26, 1866 Boult, Joseph, 15D, *Exchange-buildings*, *W*.
Oct. 19, 1868 Bower, Anthony, *Vauxhall Foundry*, and *Bowersdale*, *Seaforth*.
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Nov. 4, 1867 Bramwell, Ed., *Cowley Hill*, *St. Helens*.
Jan. 27, 1873 Bremner, H. H., 15, *Lord-street*.
Nov. 12, 1866 Browne, Edgar A., 86, *Bedford-street South*.
Oct. 18, 1869 Brown, Dr. J. Campbell, D.Sc., F.C.S., *School of Medicine*, *Dover-street*.

Oct. 30, 1876 Bulman, Richard (Messrs. Baker, Bulman & Co)., 2, *India-buildings*, *Water-street*.

Feb. 4, 1867 Burden, Edward, 128, *Upper Parliament-street*.

April 18, 1864 Burne, Joseph, *Royal Insurance Office*, 1, *North John-street*, and *Higher Tranmere*.

Nov. 12, 1866 Butler, Rev. George, *The College*, *Shaw-street*.

*May 1, 1848 Byerley, Isaac, F.L.S., F.R.C.S., *Victoria road*, *Seacombe*.

Nov. 3, 1862 Cameron, John, M.D., M.R.C.P., Physician to the Southern Hospital, and Lecturer on Medicine at the Royal Infirmary School of Medicine, 17, *Rodney-street*.

Dec. 2, 1872 Carey, Eustace, *Appleton-in-Widnes*, *near Warrington*.

Jan. 9, 1865 Cariss, Astrup, *Orange Court*, *Castle-street*.

Nov. 13, 1876 Carson, Thomas, M.D., 322, *Upper Parliament-street*.

Mar. 4, 1872 Carter, W., M.B.Lond., 74, *Rodney-street*.

Dec. 2, 1861 Chadburn, William, 71, *Lord-street*.

April 3, 1876 Chantrell, G. F., 1, *St. James's Mount*.

Oct. 18, 1869 Cook, Henry James, *Byrom-street*, and *Burbo House*, *Blundellsands*.

Dec. 13, 1875 Cowell, Peter, *Free Library*, *William Brown-street*.

Oct. 6, 1863 Crosfield, William, Jun., 8, *Temple Court*, and *Alexandra-drive*, *Ullet-road*.

Dec. 14, 1868 Daly, Dennis, 11, *Rumford-street*.

Nov. 12, 1866 Davies, E., F.C.S., *The Laboratory*, *Royal Institution*, *Colquitt-street*.

Nov. 2, 1863 Dawbarn, William, *The Temple*, *Dale-street*, and *Mossley-hill*.

Oct. 1, 1866 Dawson, Thomas, 26, *Rodney-street*.

Oct. 20, 1873 Day, George, 23, *Brunswick-street*, and *Abbey Cottage*, *Aintree*.

April 6, 1874 Dodd, John, 6, *Thomas-street*, and, 2, *Derby-terrace*, *Rock Ferry*.

Nov. 27, 1863 Dove, John M., *Claughton*.

Nov. 1, 1875 Doyle, Jas. F., 4, *Harrington-street*, and *Merton-road, Bootle.*

Jan. 28, 1848 Drysdale, John James, M.D.Edin., M.R.C.S. Edin., 36, *Rodney-street.*

Feb. 4, 1856 Duckworth, Henry, F.L.S., F.R.G.S., F.G.S., 82, *Brown's-buildings, Exchange-street, W.*

Nov. 1, 1875 Edmunds, William, *Edmond-street Chambers, Edmond-street.*

*Nov. 27, 1848 Edwards, J. B., Ph.D. Gies, F.C.S., Professor Medical Faculty of Bishop's College, *Montreal.*

Mar. 21, 1870 Edwards, Edward E. (Smith, Edwards & Co.), *Adelaide-buildings*, 4, *Chapel-street.*

Feb. 24, 1868 Elliot, John, 32, *Peter's-lane.*

April 7, 1862 English, Charles J., 26, *Chapel-street*, and 26, *Falkner-square.*

April 20, 1874 English, Robert A., 26, *Falkner-square.*

*Dec. 18, 1852 Ferguson, William, F.L.S., F.G.S., *Kinmundy House*, near *Mintlaw, N.B.*

Jan. 18, 1879 Fingland, Wm., *High-street, Wavertree.*

Nov. 15, 1875 Fleming, E. L., F.C.S., *Borax Works, Old Swan.*

Oct. 1, 1866 Fletcher, Alfred E., F.C.S., H.M. Inspector of Alkali Works for the Western District, 5, *Edge-lane.*

*Mar. 19, 1855 Foard, James Thomas, 5, *Essex-ct., Temple, E.C.*

Nov. 16, 1874 Fothergill, Charles George, 41, *Rodney-street.*

Jan. 12, 1874 Frost, John Pownall, 10, *North John-street.*

Nov. 12, 1877 Galley, Jno., 8, *Newstead-road.*

Feb. 19, 1877 Gardner, Rev. Henry, *The Hamlet, Belvidere-road.*

Nov. 29, 1875 Gardner, William, *Ash Lea, Oak-hill Park.*

Nov. 26, 1877 Gatty, Chas. T., Mayer Museum, Free Public Museum, *William Brown-street.*

*Feb. 6, 1854 Gee, Robert, M.D. Heidelb., M.R.C.P., Lecturer on Diseases of Children, Royal Infirmary School of Medicine; Physician Workhouse Hospital, 5, *Abercromby-square.*

Oct. 29, 1877 Green, Robt. Frederick, 55, *St. Domingo Vale.*
Nov. 14, 1858 Greenwood, Henry, 82, *Castle-street*, and *Stanley Park.*
Nov. 16, 1874 Grindley, Benjamin H., *Albion Office, Sir Thomas's-buildings.*
Nov. 16, 1874 Guthrie, Malcolm, 2, *Parkfield-road.*
Jan. 22, 1855 Hakes, James, F.R.C.S., Surgeon to the Northern Hospital, 80, *Hope-street.*
Oct. 18, 1875 Hale, Philip A., Bank of England, *Castle-street.*
Oct. 21, 1872 Halliwell, Joseph, 10, *College-lane.*
*Jan. 21, 1856 Hardman, Lawrence, 85, *Rock Park, Rock Ferry.*
Dec. 18, 1875 Harpin, E., 46, *Onslow-road, Elm Park, Fairfield.*
Nov. 15, 1869 Hartwig, Estevan H. L., 62, *Palmaille, Antona, Hamburg.*
Nov. 30, 1874 Harvey, Henry, M.B., *High Street, Wavertree.*
Feb. 6, 1865 Hassan, Rev. E., *Alma-terrace, Sandown-lane.*
Nov. 13, 1865 Hayward, John Williams, M.D., 117, *Grove-street.*
Feb. 6, 1865 Hebson, Douglas, 18, *Tower Chambers*, and 58, *Bedford-street South.*
Nov. 4, 1872 Hicks, Sibley, F.R.C.S., 2, *Erskine-street.*
Mar. 22, 1869 Higgin, Thomas, F.L.S., 83, *Tower-buildings*, and *Huyton.*
Dec. 28, 1846 Higgins, Rev. H. H., M.A. Cantab., F.C.P.S., *Rainhill*, Ex-President.
*Oct. 31, 1836 Higginson, Alfred, M.R.C.S., 135, *Tulse Hill, London.*
Feb. 18, 1878 Hilton, Benjamin H., Crown Life Assurance, 5a, *Exchange-buildings.*
Nov. 16, 1868 Holden, Adam, 48, *Church-street*, and 2, *Carlton-terrace, Milton-road.*
March 9, 1868 Holme, James, 10, *Huskisson-street*, and *Eldon Chambers, South John-street.*
Nov. 30, 1874 Holme, Rev. Arthur P., *Tattenhall, near Chester.*
*Dec. 14, 1862 Holt, Robert Durning, 6, *India-buildings*, and 29, *Edge-lane.*

April 9, 1877 Hooper, Richard Bennett, 6, *Loudon Grove, North Hill-street.*

Nov. 4, 1878 Howie, J. Muir, M.B., 50, *Rodney-street.*

Mar. 10, 1879 Hughes, John W., *Eden House, Breckside Park, Anfield.*

Jan. 24, 1876 Hughes, Lewis, 88, *St. Domingo-vale, Everton.*

*Nov. 18, 1854 Hunter, John, Member Historic Society, Pennsylvania, *Halifax, Nova Scotia.*

Dec. 18, 1875 Hutchinson, Joseph B., M.R.C.S., 77, *Upper Parliament-street.*

*April 29, 1850 Ihne, William, Ph.D. Bonn, *Villa Felseck, Heidelberg,* Ex-President.

Oct. 19, 1874 Imlach, Francis, M.D., 158, *Bedford-street South.*

Jan. 26, 1868 Johnson, Richard C., F.R.A.S., *Queen-buildings, Dale-street,* and *Higher Bebington,* Hon. Treasurer.

Oct. 21, 1878 Johnson, John Hampden, 22, *Queen-buildings,* 11, *Dale-street.*

Oct. 30, 1876 Johnson, James Henry, F.G.S., 64, *Albert-road, Southport.*

Mar. 19, 1877 Johnson, Rev. H. I., M.A., *Royal Institution School,* and *Penrhyn House, Ullet-road.*

Oct. 21, 1878 Johnston, Thomas B., 7, *Lord-street.*

Feb. 24, 1868 Jones, Charles W., *Field House, Wavertree.*

*April 4, 1852 Jones, Morris Charles, F.S.A., F.S.A. Scot., 20, *Abercromby-square.*

Oct. 18, 1869 Jones, William Bolton, 20, *South Castle-street.*

Nov. 26, 1877 Jones, Griffith, 335, *Upper Parliament-street.*

Nov. 30, 1874 Joseph, Rev. Morris, 67, *Canning-street.*

Oct. 21, 1878 Ker, R. Wilson, 151, *Bedford-street South.*

Nov. 1, 1869 Kinsman, W. N., 8, *Derwent-road, Stoneycroft.*

Jan. 27, 1879 Kynaston, J. W., 149, *Kensington.*

*Jan. 14, 1839 Lassell, William, F.R.SS. L. and E., F.R.A.S., *Maidenhead, Berks.*

Oct. 21, 1844 Lear, John, *Stoneby Cottage, Stoneby Green, New Brighton.*

Nov. 8, 1878 Lee, Hamilton (Messrs. Lee & Nightingale), *North John-street.*

Nov. 8, 1878 Lee, Harold (Messrs. Lee & Nightingale), *North John Street.*

Dec. 11, 1871 Leigh, Richmond, M.R.C.S.E., 141, *Park-road.*

Jan. 18, 1879 Longuet-Higgins, Henry, *Rainhill.*

Nov. 1, 1875 Lutschaunig, Alfred, *Cable-street.*

April 17, 1865 MacCheane, Wm., M.R.C.S., 47, *Shaw-street.*

Mar. 28, 1874 McCulloch, D. B., 28, *Queen-buildings, Dale-street.*

Oct. 30, 1876 McGrath, T. J., M.D., 12, *Alfred-street, Great George-street.*

April 20, 1868 Marples, David, *Lord-street* and *Cable-street*, and 5, *Mount Grove, Oxton, Birkenhead.*

Nov. 14, 1870 Marples, Joseph, 28, *Leece-street*, and *Carlton-road, Tranmere.*

Nov. 17, 1878 Marples, Josiah, *Melvill Chambers, Lord-street*, and *Broomfield, Egremont.*

Feb. 19, 1877 Marples, William, 9, *North John-street*, and *Reedville, Birkenhead.*

Feb. 9, 1874 Marsden, Peter Crook, *Lymefield, Heaton, near Bolton.*

Feb. 24, 1868 Marsh, John, *Ran Lee, Rainhill.*

Jan. 21, 1889 Martin, Studley, 27, *Brown's-buildings*, and 177, *Bedford-street South.*

Feb. 20, 1871 Mason, Alfred H., F.C.S. Lond. and Berlin, 56, *Hanover-street.*

Feb. 5, 1844 Mayer, Joseph, F.S.A., F.R.A.S., F.E.S, *Pennant House, Lower Bebington.*

Nov. 17, 1878 Mellor, James, Jun., *Weston, Blundellsands.*

Dec. 14, 1874 Mellor, John, 2, *Church-road, Walton.*

Oct. 31, 1859 Moore, Thomas John, Corr. Mem. Z.S.L., Curator Free Public Museum, *William Brown-street*, VICE-PRESIDENT.

Nov. 15, 1869 Morgan, Alfred, 126, *London-road*, and 2, *Rathbone-terrace, Wellington-road, Wavertree*, HON. LIBRARIAN.

Jan. 7, 1878 Morris, Rev. David, B.A., *Hornby-road, Walton.*

Jan. 8, 1855 Morton, George Highfield, F.G.S., 122, *London-road.*

April 16, 1849 Moss, Rev. John James, B.A., *Otterspool, Aigburth.*

Oct. 29, 1850 Mott, Albert Julius, F.G.S., 82, *Church-street,* and *Adsett Court, Westbury-on-Severn,* Ex-President.

April 8, 1854 Mott, Charles Grey, 27, *Argyle-street, Birkenhead,* and *Cavendish-road, Birkenhead Park.*

Oct. 15, 1877 Mott, Harold, 82, *Church-street.*

Dec. 16, 1878 Murphy, Rev. P., *St. Anthony's, Scotland-road.*

*Oct. 21, 1867 Muspratt, E. K., *Seaforth Hall, Seaforth.*

Oct. 20, 1865 Nevins, John Birkbeck, M.D. Lond., M.R.C.S., Lecturer on Materia Medica, Royal Infirmary School of Medicine, 3, *Abercromby-square,* Ex-President.

Feb. 6, 1865 Newton, John, M.R.C.S., 20, *Marmaduke-street, Edge-hill.*

Feb. 18, 1878 Nicholson, Robert, 11, *Harrington-street.*

Oct. 30, 1876 Nickson, John Horatio, 147, *Grove-street.*

Nov. 2, 1868 Norrie, Rev. B. A. W., M.A. Cantab., *The College School, Huyton.*

*Oct. 15, 1855 North, Alfred, 28, *Lansdown-crescent, Notting-hill, London, W.*

Jan. 8, 1877 Ogston, James, *Maresfield, Wavertree.*

Dec. 18, 1866 Owen, Peter (Farnworth & Jardine), *Liverpool and London Chambers.*

Feb. 21, 1870 Packer, James Macnamara, M.D., *Rose Cottage, Poplar Bank, Huyton.*

Nov. 2, 1874 Palmer, John Linton, F.S.A., F.R.G.S., Fleet Surgeon, R.N., 24, *Rock Park, Rock Ferry.*

Dec. 15, 1878 Parnell, E. W., 19, *Deane-road, Edge-lane.*

Nov. 16, 1874 Parratt, John, *Waterloo.*

Mar. 19, 1877 Parry, J. F., *Sandon-terrace.*

Jan. 9, 1871 Patterson, J., 16, *Devonshire-road, Prince's Park.*

Nov. 4, 1861 Philip, Thomas D., 49, *South Castle-street*, and *Holly-road, Fairfield.*

Dec. 28, 1846 Picton, James Alanson, F.S.A., Chairman of the Library and Museum Committee, 11, *Dale-street*, and *Sandy Knowe, Wavertree*, Ex-President.

Nov. 1, 1875 Picton, William Henry, *Woodlea, Waterloo Park, Waterloo.*

Feb. 24, 1879 Plastow, William, 388, *Scotland-road.*

April 30, 1866 Prag, Rev. Jacob, 99, *Upper Warwick-street.*

Mar. 18, 1872 Pringle, Adam, *Grove Park.*

Nov. 13, 1871 Proctor, Peter, M.R.C.S., and L.S.A.Lond.

Mar. 4, 1878 Radcliffe, David, 26, *Huskisson-street.*

*Jan. 22, 1866 Raffles, William Winter, *Sunnyside, Prince's Park.*

Nov. 12, 1860 Rathbone, Philip H., *Liverpool and London Chambers* (H), and *Greenbank Cottage, Wavertree.*

Mar. 24, 1862 Rathbone, Richard Reynolds, 17, *Lancaster-buildings, Tithebarn-street*, and *Beechwood House, Grassendale.*

*Jan. 7, 1856 Rawlins, Charles Edward, 12, *Rumford-court, Rumford-place*, and *Rock Mount, Rainhill.*

Jan. 9, 1870 Rawlins, Gerald W., *Brook Cottage, Rainhill.*

Jan. 7, 1878 Read, Robert, 28, *Berkeley-street.*

Nov. 17, 1851 Redish, Joseph Carter, *Lyceum, Bold-street.*

Feb. 19, 1877 Rich, J. D., *General Post Office*, and *Ivy Lodge, Linnet-lane.*

Jan. 11, 1875 Richardson, Joseph (Messrs. Laces & Co.), *Union-court*, and 98, *Bedford-street South.*

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Dec. 4, 1876 Roberts, Richard (Messrs. Roberts & Son), 18, *Hackin's-hey*, and *Mossley-hill.*

Nov. 26, 1877 Roberts, Jno. G., 27, *Hope-street.*

Feb. 4, 1867 Robinson, Joseph F., 1, *Knowsley-bs., Tithebarn-st.*

Oct. 4, 1869 Rogers, J. Frederick, 7, *Victoria-street*, and 22, *Ullet-road, Prince's Park.*

Jan. 10, 1876 Rogerson, George Russell, F.R.A.S., F.R.G.S., *Cook-st.*, and *Allerton.*

Oct. 21, 1878 Roose, Edward B., 26, *North John-street.*

Oct. 29, 1877 Rosenheim, Jos. C., *Sunny Bank, Prince's Park.*

April 18, 1854 Rowe, James, 14, *South Castle-street*, and 105, *Shaw-street.*

Jan. 22, 1872 Russell, Edward R., "*Daily Post*," *Lord-street*, and 58, *Bedford-street.*

Feb. 18, 1878 Russell, W., *Compton Hotel, Church-street.*

Feb. 19, 1877 Samuel, Douglas Ralph, 28, *Mount Pleasant, Waterloo.*

April 7, 1862 Samuel, Harry S., 11, *Orange-court*, and 2, *Canning-street.*

Nov. 30, 1874 Samuel, William Hy., 145, *Upper Parliament-street.*

Mar. 19, 1866 Sephton, Rev. John, M.A., *Liverpool Institute.*

Dec. 2, 1878 Serjeant, Jno., 128, *London-road.*

Nov. 2, 1868 Sharp, Charles, *Liverpool Institute.*

Jan. 7, 1878 Shearer, George, M.D., 157, *Upper Parliament-street.*

Nov. 16, 1868 Sheldon, E. M., M.R.C.S., 228, *Boundary-street.*

Oct. 18, 1875 Simpson, James, 10, *Rumford-place.*

Nov. 7, 1864 Skinner, Thomas, M.D.Edin., *Dunedin House*, 64, *Upper Parliament-street.*

Nov. 4, 1878 Slater, William, *The Oaks, Rock Ferry.*

Feb. 24, 1879 Slatter, G. W., A.R.C.Sc., F.C.S., 87, *Arundel-street, Prince's-road.*

Dec. 10, 1866 Smith, Elisha (Henry Nash & Co.), 12, *Tower-buildings North.*

April 4, 1870 Smith, James, 9, *Lord-street*, and *Ribblesdale Villas*, 22, *Merton-road, Bootle.*

Feb. 28, 1868 Smith, J. Simm, 1, *Warham-road, Croydon.*

Feb. 24, 1862 Snape, Joseph, Lecturer on Dental Surgery Royal Infirmary School of Medicine, 75, *Rodney street.*

Nov. 27, 1877 Snape, Thos., 11, *Mount Vernon.*

April 20, 1874 Snow, Rev. T., M.A., 55, *Seel-street.*
Dec. 2, 1878 Southward, Rev. W. T., M.A., 102, *Berkeley-st.*
Jan. 24, 1876 Souttar, Robinson, Tramway Company, 8, *Castle-street,* and 18, *Christchurch-road, Claughton, Birkenhead.*
Nov. 18, 1878 Sparke, Morton, *Charlwood House, Tarbuck-road, Roby.*
Nov. 12, 1860 Spence, Charles, 4, *Old Hall-street.*
Feb. 10, 1862 Spence, James, 18, *Brown's-buildings, Exchange,* and 10, *Abercromby-square.*
Nov. 27, 1865 Spola, Luigi, LL.D., 6a, *Hardman-street.*
Jan. 18, 1868 Stearn, C. H., Bank of England, *Castle-street,* and 8, *Eldon-terrace, Rock Ferry.*
Nov. 18, 1878 Steel, Richard, 18, *Hackin's Hey.*
Nov. 18, 1876 Stephens, Thomas English, 11, *Orange Court.*
Oct. 24, 1876 Stern, Rev. William, D.D., 8, *Hope-place.*
Nov. 1, 1875 Stevenson, John, *Prince Alfred-road, Wavertree.*
Jan. 9, 1865 Stewart, Robert E., L.D.S., R.C.S., Dental Surgeon, Royal Southern Hospital, and Liverpool Dental Hospital, 87, *Rodney-street.*
Feb. 18, 1878 Symes, Charles, Ph.D., 20, *St. James's-road.*
Mar. 4, 1878 Tanner, Alfred E., 184, *Prescot-road, Fairfield.*
Feb. 18, 1878 Taylor, Geo., 28, *Seel-street.*
*Feb. 19, 1865 Taylor, John Stopford, M.D.Aberd., F.R.G.S., 2, *Millbank-terrace, Anfield-road.*
Nov. 29, 1875 Tetley, John H., *Sunnyside,* 21, *Rock Park, Rock Ferry.*
Feb. 19, 1877 Thacker, Reginald P., *Mandeville, Aigburth-road.*
Oct. 21, 1878 Thompson, J. W. (Gill & Archer), 14, *Cook-street.*
Nov. 17, 1850 Tinling, Chas., *Victoria-street,* and 29, *Onslow-road, Elm Park.*
Dec. 4, 1876 Torpy, Rev. Lorenzo, M.A., *St. John's, Toxteth Park.*
*Feb. 19, 1844 Turnbull, James Muter, M.D.Edin., M.R.C.P., Physician, Royal Infirmary, 86, *Rodney-street.*

Oct. 21, 1861 Unwin, William Andrew, 11, *Rumford-place.*

Dec. 2, 1872 Waite, Wm. Henry, D.D.S., L.D.S., 10, *Oxford-street.*

Mar. 18, 1872 Walker, George E., F.R.C.S., 48, *Rodney-street.*

Feb. 24, 1879 Walker, R. S., J.P., Resident Secretary, General Insurance Co., 5, *Lord-street.*

Mar. 18, 1861 Walker, Thomas Shadford, M.R.C.S., 88, *Rodney-street.*

Jan. 27, 1862 Walmsley, Gilbert G., 50, *Lord-street.*

Jan. 9, 1865 Walthew, William, *Phœnix Chambers*, and *Vine Cottage, Aughton.*

Feb. 19, 1877 Wallace, John, M.D., *Gambier-terrace.*

Mar. 4, 1872 Ward, Thomas, *Brooklands House, Northwich.*

Dec. 2, 1861 Weightman, William Henry, *Minster-buildings, Church-street*, and *Cambridge-road, Seaforth.*

Oct. 30, 1876 Weightman, Arthur (Messrs. Field & Weightman), *Talbot Chambers*, 8, *Fenwick-street, W.*

Oct. 29, 1877 Whalley, Edward, 9, *Mona-terrace, Bedford-road, Rock Ferry.*

April 7, 1862 Whittle, Ewing, M.D., Lecturer on Medical Jurisprudence, Royal Infirmary School of Medicine, 77A, *Upper Parliament-street.*

Nov. 2, 1874 Wolf, Jas. O. de (Messrs. T. C. Jones & Co.), 26, *Chapel-street.*

Mar. 18, 1861 Wood, George S. (Messrs. Abraham & Co.), 20, *Lord-street*, and *Bellevue-road, Wavertree.*

Nov. 14, 1870 Wood, John J. (Messrs. Abraham & Co.), 20, *Lord-street.*

Nov. 18, 1878 Wright, J. Powell, Lecturer on Physiology and Histology, Liverpool School of Science, 8, *Dover-street.*

Nov. 29, 1875 Yates, D. E., 9, *Rumford-place*, and 88, *Huskisson-street.*

Nov. 13, 1876 Yates, Edward Wilson, 87, *Castle-street.*

Nov. 2, 1874 Young, Henry, *South Castle-street.*

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1.—1833 The Right Hon. Dudley Ryder, Earl of Harrowby, K.G., D.C.L., F.R.S., etc., *Sandon Hall, Staffordshire* and 39, *Grosvenor-square, London, W.*

2.—1836 The Most Noble William, Duke of Devonshire, K.G., M.A., F.R.S., D.C.L., F.G.S., etc., Chancellor of the University of Cambridge, *Chatsworth, Derbyshire, etc.*, and 78, *Piccadilly, London, W.*

3.—1838 Sir George Biddell Airy, K.C.B., M.A., LL.D., D.C.L., F.R.S., F.R.A.S., etc., Astronomer Royal, *Royal Observatory, Greenwich.*

4.—1840 James Nasmyth, F.R.S., *Penshurst, Kent.*

5.—1844 T. B. Hall, *Crane House, Yarmouth.*

6.—1844 Peter Rylands, M.P., *Warrington.*

7.—1844 Thomas Rymer Jones, F.R.S., F.Z.S., F.L.S., etc., 52, *Cornwall-road, Westbourne Park, London, W.*

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13.—1861 The Rev. Thomas P. Kirkman, M.A., F.R.S., Rector of Croft, *near Warrington.*

14.—1865 The Right Rev. T. N. Staley, D.D., late Bishop of Honolulu, Vicar of Croxhall, *Staffordshire.*

15.—1865 Edward J. Reed, C.B., M.P., *Hull.*

16.—1865 George Rolleston, M.D., F.R.S., Linacre Professor of Physiology in the University of Oxford, *Oxford.*

17.—1865 Cuthbert Collingwood, M.A., M.B., F.L.S., etc.

18.—1867 J. W. Dawson, LL.D., F.R.S., etc., Principal and Vice-Chancellor of McGill University, *Montreal.*

19.—1868 Captain Sir James Anderson, 16, *Warrington Crescent, Maida Hill, London, W.*

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23.—1870 Sir Joseph Dalton Hooker, M.D., F.R.S., etc., *Royal Botanic Gardens, Kew.*

24.—1870 Professor Brown Séquard, M.D.

25.—1870 John Gwyn Jeffreys, F.R.S., 25, *Devonshire-place, Portland-place, London, W.*

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28.—1870 The Rev. Christian D. Ginsburg, LL.D., *Binfield, Bracknell, Berks.*

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36.—1877 Adolphus Ernst, M.D., Principal of the Department of Science, Philosophy, and Medicine, *Caraccas.*

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38.—1877 Dr. Franz Steindachner, Royal and Imperial Museum, *Vienna.*

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1.—Jan. 27, 1862 Captain John H. Mortimer, "America." (Atlantic.)

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3.—Feb. 9, 1863 Captain James P. Anderson, Cunard Service. (Atlantic.)

4.—Feb. 9, 1863 Captain John Carr (Bushby & Edwards), ship "Scindia." (Calcutta.)

5.—Feb. 9, 1863 Captain Charles E. Price, R.N.R. (L. Young & Co.), ship "Cornwallis." (Calcutta and Sydney.)

6.—April 20, 1863 Captain Fred. E. Baker, ship "Niphon." (Chinese Seas.)

7.—Oct. 31, 1864 Captain Thomson, ship "Admiral Lyons." (Bombay.)

8.—Oct. 31, 1864 Captain Alexander Browne (Papayanni), S.S. "Agia Sofia." (Mediterranean.)

9.—April 18, 1865 Captain Alexander Cameron (Boult, English & Brandon), ship "Staffordshire." Shanghai.)

10.—Dec. 11, 1865 Captain Walker, ship "Trenton."

11.—Mar. 28, 1868 Captain David Scott.

12.—Oct. 5, 1868 Captain Cawne Warren.

13.—Oct. 5, 1868 Captain J. A. Perry.

14.—Mar. 22, 1869 Captain Robert Morgan, ship "Robin Hood."

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St. Petersburg . . L'Académie Imperiale des Sciences.
Stockholm . . . *L'Académie Royale Suedoise des Sciences.
Strasburg . . . La Bibliothèque Municipale.
Strasburg . . . Die Kaiserliche Universitäts und Landesbibliothek.
Sydney . . . . *The Royal Society of New South Wales.
Taunton . . . The Somersetshire Archæological Society.
Toronto . . . . *The Canadian Institute
Truro . . . . *The Royal Institution of Cornwall.
Vienna . . . . Der Kaiserlichen Akademie der Wissenschaften.
Vienna . . . . *Der Geographischen Gesellschaft.
Whitby . . . . *The Literary and Philosophical Society.
Washington . . *The Naval Observatory.
Washington . . *The Department of Agriculture.
Washington . . *The Smithsonian Institution.

Washington . . *The War Office:—The Ordnance Department; the Office of the Chief Signal Officer U.S. Army; the Department of the Chief of Engineers U.S. Army; the Department of the Paymaster-General U.S. Army; the Department of the Surgeon-General U.S. Army.

Washington . . *The U.S. Geological and Geographical Survey of the Territories.

Wellington, N.Z. . . *The New Zealand Institute.

York . . . . *The Philosophical Society.

TREASURER'S ACCOUNT, 1878-9.

Dr. *The Literary and Philosophical Society in Account with* R. C. JOHNSON, *Treasurer.* **Cr.**

1877-8.	£	s.	d.
To Balance brought forward	52	4	10
„ Cash paid Messrs. Marples & Co., Printing	159	17	8
„ „ Mr. G. G. Walmsley, Binding	6	11	11
„ „ Messrs. Tinling & Co., Circulars	12	18	6
„ „ Secretary's Expenses	19	9	0
„ „ „ Editorial Fee	10	10	0
„ „ Mr. Doling, Refreshments	32	18	0
„ „ Mr. Burke, Attendance	1	17	6
„ „ Librarian's Expenses	3	5	6
„ „ Treasurer's „	0	18	6
„ „ Rent of Rooms	20	0	0
„ Balance in hand, viz., Dock Bond	150	0	0
„ Cash	19	8	1
	£489	4	1

Audited and found correct,

EDWARD DAVIES.
ISAAC ROBERTS.

1877-8.	£	s.	d.	£	s.	d.
By Balance brought forward				250	0	0
„ Cash for Subscriptions—						
Entrance Fees, at 10s. 6d.	14	14	0			
Annual „ 21s.	197	8	0			
„ „ 10s. 6d.	4	14	6			
Arrears, 21s.	11	11	0			
				228	7	6
„ Interest on Dock Bonds				10	16	7
				£489	4	1
„ Balance, Dock Bond	150	0	0			
„ Cash	19	8	1			
				£169	8	1

PROCEEDINGS

OF THE

LIVERPOOL LITERARY AND PHILOSOPHICAL SOCIETY.

ANNUAL MEETING.—SIXTY-EIGHTH SESSION.

ROYAL INSTITUTION, October 7th, 1878.

JOHN J. DRYSDALE, M.D., M.R.C.S., PRESIDENT, in the Chair.

THE Minutes of the last Meeting of the preceding Session were read and confirmed, after which the following Report was read by the Honorary Secretary:—

REPORT.

The unabated interest which continues to mark the Proceedings of the Literary and Philosophical Society renders the presentation of an Annual Report an easy and agreeable task; and the Council feels that in addressing the Members at the commencement of the sixty-eighth Session, it is justified in congratulating them upon the success which crowns their efforts to maintain the Society in its efficiency and reputation. The numerously-attended meetings, the keen discussions of the principal scientific questions of the day, and the character of the papers read,

all bear witness to the Society's intellectual activity, and to the earnestness of its Members in the cultivation of literature and philosophy.

This was particularly shown during the last Session by the promptness with which the Members adopted the recommendation of the Council, that the kindred Societies of Liverpool should be invited to join the Literary and Philosophical Society in holding a Soirée, wherein the Associated Societies should exhibit objects, specimens, and scientific appliances illustrative of their respective departments of study, and further indicate the character and quality of their work by lectures and experiments. The remarkable success which attended this first Associated Soirée of the Literary, Scientific, and Art Societies of Liverpool induces your Council to recommend a renewal of the Society's invitation for an early meeting of delegates, to consider the desirability of holding a second Soirée.

Your Council has the gratification of reporting that the strength of the Society is now greater than at any former period, the number of Ordinary Members on its roll being two hundred and forty-six. Two names have been removed by death since the last Session, those of Mr. James Aikin, who had been a member for forty-five years, and of Mr. Christopher Bell, who had been connected with the Society for twenty-three years. Seventeen Members have resigned, and twenty-nine new Members have been admitted.

The names of two Honorary Members who have done some service for the Society will be missed from the roll, viz., the Rev. Dr. Booth, F.R.S., and Professor Henry.

Dr. Booth had been connected with the Society since 1844, in which year he was elected an Ordinary Member, being at that time Vice-Principal of the Collegiate Institution in Shaw Street. Two years afterwards he was elected to the Presidential Office, and on his removal from Liverpool

was made an Honorary (then termed Corresponding) Member in 1853. Besides papers and addresses, Dr. Booth contributed donations to the Society's library, and only just before his death, in April last, he forwarded to the Hon. Librarian a copy of his work on some New Geometrical Methods, in two volumes, for presentation to the Society.

Professor Henry, LL.D., of the Smithsonian Institution, Washington, had likewise earned the distinction conferred upon him by the Society in 1870, by frequent donations to the library of the valuable and varied publications issued by the Institute of which he was the first Secretary and Director. To none of its correspondents is the Literary and Philosophical Society more indebted for donations than to the kindred Societies and Institutions of North America: prominent among these is the Smithsonian Institution, and the Council feels assured that the Members of this Society will mourn the loss of their Honorary Member, in sympathy with the regents of that Institution, which, by the devotion of a lifetime, Professor Henry made what its founder intended it to be, an efficient instrument for the "increase and diffusion of knowledge amongst men."

With the exception of these two names, the lists of Honorary and Corresponding Members, and of the Associates, remain unaltered; but it will be necessary to consider the re-election of the following gentlemen, whose terms as Corresponding Members are expired: The Rev. J. Holding, M.A., F.R.G.S., London; Mr. George Hawkins, Colombo, Ceylon; and Mr. J. Lewis Ingram, Bathurst, River Gambia.

The volume of Proceedings for the last Session has now passed through the press, and it is hoped that copies will be ready for distribution before the end of the present month.

A representation having been made to the Council that a portion of the duties assigned by the Laws to the Secretary

is now more appropriately performed by the Librarian, the following alterations, in conformity with this change, are recommended for acceptance :—

That Law XXXIV. shall be extended by the insertion of the following paragraph after the word "Members:" — "He shall receive, acknowledge, and record all donations presented to the library; shall cause the volume of Proceedings to be forwarded to those Societies and Institutions with which the Society is in correspondence, and shall maintain such other communications with them as may be desirable (under the direction of the Council)."

And that Law LIX. shall read as follows :—"All donations shall be duly recorded by the Secretary in the minutes of the Society, and in the next volume of the Proceedings."

The Council concludes this Report with the recommendation of the following gentlemen to serve on the new Council for the ensuing Session :—James Simpson, George Russell Rogerson, F.R.A.S., &c., Harry S. Samuel, the Rev. Dr. Stern, and Baron L. Benas.

The Report was approved and adopted, on the motion of the Rev. H. H. Higgins, seconded by Mr. G. F. Chantrell.

The Treasurer's Accounts for the past Session were next submitted and passed, on the motion of Dr. Nevins, seconded by Mr. Guthrie. It appeared, however, that one of the Society's Dock Bonds of the value of £100 had fallen due, and that it had been used for current expenses. This was also approved, but it was recommended that the Council should take into immediate consideration the financial position of the Society, and report thereon as early as convenient.

The election of officers was then proceeded with, and the following gentlemen were elected to the offices named :—

Vice-Presidents—Thos. J. Moore, Cor. Mem. Z.S.L.; Edward R. Russell; Thos. Higgin, F.L.S.

Honorary Treasurer—Richard C. Johnson, F.R.A.S.

Honorary Secretary—James Birchall.

Honorary Librarian—Alfred Morgan.

Council—J. Campbell Brown, D.Sc.; Isaac Roberts, F.G.S.; G. H. Morton, F.G.S.; W. Carter, M.B.; John W. Hayward, M.D.; Edward Davies, F.C.S.; Malcolm Guthrie; Alfred E. Fletcher, F.C.S.; Josiah Marples, and the following five gentlemen nominated by the retiring Council, namely,—James Simpson; G. Russell Rogerson, F.R.A.S., F.R.G.S.; Harry S. Samuel; Rev. Wm. Stern, M.D.; and Baron L. Benas.

The following Corresponding Members, whose term of ten years had expired, were re-elected:—Rev. J. Holding, M.A.; Geo. Hawkins, Colombo; and J. Lewis Ingram, Bathurst, River Gambia.

The Associates were also re-elected.

In conformity with the recommendation contained in the Annual Report, the Secretary was duly authorised to call a meeting of delegates from the kindred Societies to consider the advisability of holding a second Associated Soirée.

The revision of Laws XXXIV. and LIX., defining the respective duties of the Secretary and Librarian, as recommended in the Report of the Council, was next formally passed and approved of.

The routine business of the Annual Meeting being thus completed, the President proceeded to deliver his second Inaugural Address.*

* See page 1.

FIRST ORDINARY MEETING.

ROYAL INSTITUTION, October 21st, 1878.

JOHN J. DRYSDALE, M.D., M.R.C.S., PRESIDENT, in the Chair.

Messrs. H. C. Beasley, Wm. Adair, J. Wilson Ker, J. W. Thompson, Thos. B. Johnston, Jno. Hampden Johnson, and E. B. Roose were duly elected Ordinary Members.

The Rev. H. H. HIGGINS described a collection of rare plants from the Botanic Gardens, exhibited by the Curator (Mr. Richardson), and the following communication was then read :—

THE RED CORAL OF COMMERCE—*Corallium rubrum*, Lamarck.

BY THE REV. H. H. HIGGINS, M.A.

The living animal of the Red Coral in its structure resembles a Sea Anemone ; it therefore belongs to the second, or lowest but one, of the great divisions of the animal kingdom, *Cœlenterata*. This extensive sub-kingdom includes also the fresh-water Hydra, the Sertularian Zoophytes, Jelly-fish, the Portuguese Man-of-War, the stony corals, the black coral (*Antipathes*), Sea-pens, flexible corals (*Gorgonia*), Sea-fingers, and the beautiful, pellucid, melon-shaped *Cydippe*.

The stony corals, as seen in museums, are true skeletons secreted within the tissues of living polypes. It is not so with the coral of commerce, which is a foot secretion of an external character, more resembling shell; except that the mollusc lives in its shell and the coral polype upon it. The red coral, when first taken from the sea, has a hard axis covered by a soft bark or rhind, in the substance of which

reside the polypes. These are white, and have eight delicately-fringed tentacles, the fully expanded polype being in miniature not unlike the petals of the common Buck-bean. The fertilising and ova-bearing polypes are generally distinct, and occupy separate branches; but, in certain cases, both sexes are united in the same polype.

In the bark of the flexible corals, as also in the integument of some Tunicates and Sea-cucumbers, are found little detached calcareous crystals, called sclerites, mostly microscopic in size and variable in shape. Scattered through the friable bark, these minute sclerites serve to give it the requisite firmness and consistency; but the axis of the red coral of commerce seems to be entirely made up of sclerites welded or fused together. So far as I am aware, this peculiarity in the red coral has not long been known. The members of the Liverpool Microscopical Society will, no doubt, be ready to prepare the thin sections of coral requisite for the illustration of this interesting fact, which belongs to a numerous class of inducements held out by Nature to encourage observation. The botanist recognises in the stamen of a flower a transformed leaf; and the histologist knows that the horn of the Rhinoceros is made up of hair firmly welded together. So these little sclerites or spicules, which have so often been seen as particles of crystal dust on the slide of the microscope, now appear under quite a new aspect; transformed and blended together, they constitute the substance of the noble or precious coral.

The principal fisheries of red coral are in the Mediterranean. I have been told that it extends to the coasts of the Atlantic, south of the Straits of Gibraltar, and north of the tropic of Cancer. An official of the Japanese government, who lately visited the Liverpool Museum, stated that red coral occurred in the seas of China and Japan; but all the best authorities to the present date agree in regarding

Corallium rubrum as a Mediterranean species. M. Milne Edwards mentions two other species, inferior in size and beauty, belonging to the same genus. It seems doubtful whether *Corallium* has been found in the geological series earlier than the Miocene period.

Red coral is found at depths varying from six fathoms to one hundred and twenty fathoms. The mode of fishing for it is sufficiently primitive. A heavily-weighted beam, to which are attached bundles of hempen tangles, is sunk in the sea and dragged along the bottom. On being drawn up, fragments of coral are found in the tangles. The breakage and waste must be enormous; the wonder is not that fine specimens should be rare, but rather that any at all should ever be secured. The coral fisheries of Algeria are divided into ten marine districts, one of which only is fished every year. By this it would appear that ten years are considered to be a sufficient period for the red coral to attain its full size.

A very extensive trade in coral was in ancient times carried on from the Mediterranean to India and the East. In China it is regarded as possessing talismanic properties, and is worn both as an ornament and an amulet. Very high prices have been given for fine specimens; and the pale rose-coloured variety is said to have realised more than eighty pounds per ounce.

In the book of Job coral is classed with treasures such as pearls and rubies; and the prophet Ezekiel, apostrophising the city of Tyre because of its wealth and magnificence, declares, "Syria was thy merchant in emeralds and broidered work and coral." In St. Mark's Square, Venice, as I am informed by my friend Dr. Nevins, very expensive sets of coral jewellery are exhibited by the goldsmiths. It is not so fashionable in this country as it used to be; but I may be pardoned for being so unscientific as to confess that I love to see a pretty child wearing a simple necklace of beads of red

coral. The Greeks, in the time of Aristotle, must have admired it when they gave to it the name of ΚΟΡΑ'ΛΙΟΝ, from κόρη, a young virgin, and ἁλὸς, of the sea: the maiden daughter of the sea.

The specimens exhibited to-night are three in number. They belong to the Liverpool Museum, and are the finest I have anywhere seen. One of them is still affixed to the matrix, and is in its natural condition, in which the surface is regularly striated. The bark is thin and very fugacious, but may be seen on some portions of the specimen. It is, I believe, the true *Corallium rubrum* of Linnæus from the Mediterranean. The other two have, I think, been polished, but it is possible they may belong to another species of the genus *Corallium*. They were brought to Liverpool from Japan. The larger of the two was in a casket, the interior of which was shaped to fit the specimen, and lined with silk.

The Rev. H. H. Higgins also contributed the following description of a Fungus recently found at New Brighton:—

Agaricus (*Clitocybe*) *crenatus*, n.s.?

Pileus somewhat fleshy, one inch broad; umbilicate, pale flesh-coloured, clothed with purple-brown raised fibrillæ, in streaks; margin involute, regularly crenate, purple black; gills, pale flesh-coloured, emarginate; stem, three inches long, tough, compressed; spores, variable in form, pale, but not quite colourless.

This singularly beautiful Agaric, which occurred in perfect condition, differs from all the forms of *A. Laccatus* I have seen, in the contrast between the purple raised scales of the pileus, and the pale rose-colour of the surface below; in the gills, which are more crowded, and in the *black* crenate margin. It was growing on a sandy dune, in company with *Geaster Bryantii* and *Tulostoma mammosum*.

Mr. T. J. Moore exhibited the following objects, recently added to the Free Public Museum:—

A fine adult male specimen of the Himalayan Langur (*Presbytis schistaceus*, Hodgson), a monkey closely related to the Entellus, from an elevation of about eight thousand feet in the pine and birch woods of Kashmir; collected and presented, with other Mammals and Birds from Kashmir, Ladakh, and Baltistan, by Mr. St. George Littledale.

Specimen of *Nectarinidæ* and other Birds, chiefly from the Amaswazi and Bamangwato countries, South Africa; collected and presented by Mr. R. M. Brooke, Norton Priory.

A Skin of the Kiang, or Wild Ass (*Equus hemionus?* Pallas), shot in Ladakh, and presented by Mr. O. Heywood Jones.

A stuffed specimen of the rare marine Lizard, *Amblyrhynchus cristatus*, from the Galapagos Islands; collected and presented by Capt. Thomas Strick, barque *Arica*.

A young Apteryx in the egg, and other specimens from New Zealand; collected and presented by Col. Trimble.

A living specimen of the Amphiuma, or Congo Snake (*Amphiuma means*), from New Orleans, presented by Capt. J. A. Perry, Associate.

Specimens of Fish, Shells, Sponges, &c., from the Red Sea, Burmah, &c., collected and presented by Capt. Sibthorpe, s.s. *European*.

Dr. Nevins next read a short paper on Ostrich Farming, and was followed by Mr. Guthrie, who described the manufacture of Ostrich Plumes.

Mr. Arthur Nevins, Associate, gave an account of his recent visit to the Keeling or Cocos Islands, now largely

resorted to for water-supplies by vessels trading with horses from Australia to India. During his brief stay for such a purpose, Mr. Nevins made a small collection of Shells; these had been presented by him to the Free Public Museum, and determined by Mr. Marrat, from whom the following communication was read :—

NOTE ON SHELLS FROM THE KEELING OR COCOS ISLANDS, INDIAN OCEAN.

By F. P. MARRAT.

Keeling's Islands, or Cocos Islands as they were formerly named, were a few years since selected by the late Mr. Keen and myself as one of the most likely spots in the whole ocean range to contain vast numbers, and consequently a great variety, of shells. Mr. Keen obtained the name of the owner, Mr. Ross, to whom he wrote requesting him to gather any of the small shells, easily obtainable on the shore. The result of this communication was a prompt reply, and a small box containing a very large number of species, such as to rather whet our appetites than lull our cravings for more. The following shells were selected from the lot :—Cypræaovula adamsonii, *Gray*, bleached ; Trivia insecta, *Migh.*; pellucidula, *Gask.*; Oryza, *Sam.*; scabriuscula, *Gray*, and another very like the rare T. producta, *Gask.*, but in bad condition. Some of the elongated and cancellated Pleurotomoid forms were among the most graceful it is possible to conceive, even vying with their brethren in the Mitroid group.

Although the sixteen genera and species brought by Mr. Nevins are of the commonest description, they are large shells, and, taking them in connection with the small species previously mentioned, I should say that the Molluscan fauna is a very rich one, and probably little inferior to that of the celebrated Philippines, immortalised (speaking conchologically) by the late Hugh Cuming.

Cypræa tigris, *Linn.*
" mauritiana, *Linn.*
" erosa, *Linn.*
" lynx, *Linn.*
" isabella, *Linn.*
" histrio, *Gmel.*
" vitellus, *Linn.*
" arabica, *Linn.*
Dolium oleareum, *Brug.*
" pomum, *Linn.*
Tritonium tritonis, *Linn.*
Terebra, crenulata, *Linn.*
" subulata, *Linn.*
Harpago, *Klein.*
Heptadactylus radix-bryoniæ, *Gmel.*
Tellina, *Linn.*
Arcopagia, *Leach.*
scobinata, *Linn.*
Chametrachæa, *Klein.*
Tridacna, *Da Costa*; crocea, *Lam.*

The following communication was then read :—

NOTE ON SHELLS FROM THE MALDIVE ISLANDS, BROUGHT BY CAPTAIN SLACK, ASSOCIATE OF THE SOCIETY.

By F. P. MARRAT.

Capt. Slack, Associate of this Society, presented to our Free Public Museum, some time since, about twenty species of shells, purchased by himself at Ceylon, and which he ascertained, by direct evidence, to come from the Maldive Islands, in the Indian Ocean. These shells, together with others obtained from the neighbouring Laccadive Islands, were all belonging to Philippine species, thus extending the geographical range in which these shells are said to have been found. It would be interesting if we could ascertain the centres of radiation of these and similar groups, and determine the causes of deviation to which they are at present, or were formerly, subject. The oceanic currents must be the principal means by which they are transported, hence the apparent deviations that seem to exist. In the present instance, these currents pass from the Philippines round the island of Ceylon, stretch out, and absolutely enclose the Maldives; another branching current rushes along the eastern shore of the Bay of Bengal, and shells of

a like character are also found here, off the Andaman Islands.

Most of the writers on shells, such as Reeve, Sowerby, and Adams, in this country; Carpenter, Binney, Gould, and Dahl, in America; Kiener, Dunker, and Krauss, in Germany; Chenu, Crosse, Lamarck, in France, are silent on this important subject; and nearly all the authors now living lay considerable stress in their specific descriptions on the localities in which the shells they describe are found.

Cypræa helvola.
" vitellus.
" arabica.
" lynx.
" carneola.
" ocellata.
" moneta.
" asellus.
" caput-serpentis.
Turritella duplicata.
Murex haustellum.
" adunco-spinosa.
Harpa ventricosa.
Harpa conoidalis.
Pyrena atra.
Conus hebræus.
Cassis rufa.
Natica mamilla.
Helix juliana.
" melanotragus.
Oliva ispidula.
" var.
" var.
" var.
Cytherea impudica.

SECOND ORDINARY MEETING.

Royal Institution, November 4th, 1878.

JOHN J. DRYSDALE, M.D., M.R.C.S., President, in the Chair.

Mr. W. Slater and Dr. Howie were elected Ordinary Members.

The Rev. H. H. Higgins read a paper on the question, "Is Nature Cruel?" which occupied the whole of the evening. *

* See page 75.

THIRD ORDINARY MEETING.

Royal Institution, November 18th, 1878.

JOHN J. DRYSDALE, M.D., M.R.C.S., President, in the Chair.

Messrs. J. Powell Wright, Richard Steele, and Morton Sparke were elected Ordinary Members.

The evening was occupied in a discussion on the paper read at the last meeting, "Is Nature Cruel?" The speakers were Mr. Ball, Rev. H. J. Johnson, and Messrs. Russell, Hayward, Unwin, Snape, Samuel, Symes, Patterson, and Dr. Nevins.

FOURTH ORDINARY MEETING.

Royal Institution, December 2nd, 1878.

JOHN J. DRYSDALE, M.D., M.R.C.S., President, in the Chair.

Messrs. John Serjeant and W. T. Southward, M.A., were elected Ordinary Members; and Captains Sibthorpe and Cooper, Associates.

The Rev. H. H. Higgins introduced Mr. McDonnell, Master-at-Arms of H.M.S. *Resistance*, who exhibited an extensive collection of insects naturally entombed in Gum Copal, taken in East Central Africa.

The Rev. H. H. Higgins exhibited a specimen of White Coral, probably a variety of the Red Coral of Japan; and a rare Mollusc, *Teredo* (*Uperotis*) *nucivora*, whose habitat is in the husk of a Cocoa Nut.

Mr. GUTHRIE then read a paper entitled "A Critical Examination of Mr. Herbert Spencer's Explanation of the Evolution of Organic Matter."

FIFTH ORDINARY MEETING.

ROYAL INSTITUTION, December 16th, 1878.

JOHN J. DRYSDALE, M.D., M.R.C.S., PRESIDENT, in the Chair.

The Rev. P. Murphy and Mr. R. Lachlan Bogue were elected Ordinary Members.

Mr. T. HIGGIN, F.L.S., exhibited two new and rare Sponges (*Aphrocallistes beatrix* and *Eurete megalostoma*) lately added to the Museum collection, and spoke of some interesting Sponge-balls lately brought to this country, analogous to the "Hairball" of the Ox, and to the "Ambergris Ball" of the Sperm Whale. These Sponge-balls are masses of comminuted spicules, and portions of the skeletons of the Euplectellæ, and they are supposed to have been cast up on the shore, after being thrown up by some cetacean animal that had been browsing on the Euplectellæ.

Some specimens of Carrara marble, completely honeycombed by the action of the boring Sponge *Cliona*, having been exhibited by Captain MORTIMER, Associate, being part of a cargo wrecked off Long Island in 1871, and alluded to in *Silliman's Journal*, November, 1878, p. 406, Mr. HIGGIN showed examples of the *Cliona* in various stages, boring into shells, converting them to its own substance, and finally becoming free. This wrecked cargo of Carrara marble was thus slowly being consumed, and becoming converted into

living sponge substance, having a skeleton of siliceous spicules.

Mr. Alfred Morgan then read a paper on "A description of a Dakotan Calendar, with a few ethnographical and other notes on the Dakotas, or Sioux Indians, and their territory." *

SIXTH ORDINARY MEETING.

Royal Institution, January 13th, 1879.

JOHN J. DRYSDALE, M.D., M.R.C.S., President, in the Chair.

Messrs. Henry Longuet Higgins and Wm. Fingland were elected Ordinary Members.

References were made to the recent death of Mr. Hugh Shimmin, who had been a member of the Society for thirteen years.

Dr. Carter briefly reported an experiment he had made to illustrate the filtering power of a thin layer of sand.

Mr. R. C. Johnson stated that on the recent occasion of an explosion of forty-five pounds of dynamite, at Holywell, the sound was distinctly heard at Higher Bebington, a distance of ten miles.

Mr. Picton made some observations on a communication he had received from Australia, describing the fall of a shower of sulphur, as was supposed. Dr. Carter and the Rev. H. H. Higgins considered that the supposed sulphur was most likely the pollen of the willow, &c.

* See page 233.

Mr. J. LINTON PALMER, Fleet Surgeon, R.N., then read a paper on "The Colours of the Sea."*

SEVENTH ORDINARY MEETING.

ROYAL INSTITUTION, January 27th, 1879.

JOHN J. DRYSDALE, M.D., M.R.C.S., PRESIDENT, in the Chair.

Messrs. J. W. Kynaston and C. H. Beloe were elected Ordinary Members.

Mr. JOSEPH BOULT introduced the subject of overcrowding in our large towns in its influence upon the rates of mortality, and quoted statistics to show that overcrowding, in the sense of so many persons to the acre, was by no means so important an element in the causes of high mortality as was generally supposed. These causes, he considered, were to be found rather in the habits of the people than in the character of their dwellings. An interesting discussion followed, supported by Messrs. Picton, Fletcher, Shearer, Russell, and Symes.

The PRESIDENT, in summing up the discussion, said that whilst they fully acknowledged the importance of the subject and the value of Mr. Boult's statistics, they should also admit the merit of what had been done in improving the sanitary condition of towns, and not consider that the money spent had been wasted. In Liverpool, he thought the chief error committed had been in allowing small and inferior cottage property to be built, instead of encouraging the erection of a larger class of property to be let off in tenements.

A paper was then read by Mr. E. DAVIES, F.C.S., "On

* See page 117.

Mr. Norman Lockyer's Hypothesis of the Compound Nature of the Elements."

After which, Mr. Stearn read a paper, illustrated with experiments, "On Professor Crookes's Researches into an Ultra Gaseous state of Matter."

EIGHTH ORDINARY MEETING.

Royal Institution, February 10th, 1879.

EDWARD R. RUSSELL, Vice-President, in the Chair.

The Honorary Secretary reported the results of the Associated Soirée, held on the 31st ultimo. The tickets taken represented 2,774 visitors; and the receipts amounted to the sum of £300, leaving a balance in the hands of the Executive Committee of £22.

The Rev. T. P. Kirkman, M.A., F.R.S., presented a paper on "The Solution of the Autopolar Poly-edra, with full constructions up to P = 10." *

Mr. F. P. Marratt exhibited an extensive collection of shells of the genus *Nassa*, and read a communication thereon. †

Mr. Arthur E. Nevins, Associate, then read a paper "On Modern Meteorology considered in its Bearing upon Tropical Storms." ‡

NINTH ORDINARY MEETING.

Royal Institution, February 24th, 1879.

JOHN J. DRYSDALE, M.D., M.R.C.S., President, in the Chair.

Messrs. George W. Slatter, A.R.C.Sc., F.C.S., Wm.

* See page 133. † See page 255. ‡ See page 101.

Plaistow, and R. S. Walker, J.P., were elected Ordinary Members.

A resolution was unanimously carried, on the motion of the Rev. H. H. Higgins, seconded by Dr. Nevins, that the President be requested to express to Mr. Picton the cordial sympathy of the Society in the recent loss of his wife.

Dr. Shearer read a brief communication on Sanitary Science as affecting the overcrowding of our large towns and the rates of mortality.

Dr. Nevins then read a paper "On the Translation of *Διδάσκᾰλος, πειράω, πειράζω,* and *το πτερύγιον*, in the Authorised Version of the New Testament." *

TENTH ORDINARY MEETING.

Royal Institution, March 10th, 1879.

JOHN J. DRYSDALE, M.D., M.R.C.S., President, in the Chair.

Arrangements were made for inviting the kindred Societies to hold a third Associated Soirée at the close of the year.

Mr. Jno. W. Hughes was elected an Ordinary Member.

Mr. Richmond Leigh, M.R.C.S.E., read a paper "On Change of Climate—Secular, and caused by human agency." †

ELEVENTH ORDINARY MEETING.

Royal Institution, March 24th, 1879.

JOHN J. DRYSDALE, M.D., M.R.C.S., President, in the Chair.

Dr. Alexander was elected an Ordinary Member.

* See page 191. † See page 169.

The Hon. Treasurer was authorised to receive subscriptions towards the Testimonial Fund, now being raised in London for the benefit of the late Professor Clifford's family.

Mr. CHANTRELL referred to the recent death at sea of Captain Perry, Associate, and spoke in high terms of his skill and enthusiasm in the pursuit of microscopical science. Several Members also bore testimony to the zeal and ability of the deceased Associate, and a resolution was unanimously agreed to, that a letter of condolence be sent to his widow.

Mr. JOSEPH BOULT read a paper "On the Genesis of the Tides."

TWELFTH ORDINARY MEETING.

ROYAL INSTITUTION, April 7th, 1879.

EDWARD R. RUSSELL, VICE-PRESIDENT, in the Chair.

Dr. NEVINS exhibited a Blind Crayfish, *Cambarus pellucidus*, caught in the river Echo, Mammoth Caves of Kentucky.

Dr. FRANCIS IMLACH read a paper on "The Levantine Plague—Past and Present." *

THIRTEENTH ORDINARY MEETING.

ROYAL INSTITUTION, April 21st, 1879.

JOHN J. DRYSDALE, M.D., M.R.C.S., PRESIDENT, in the Chair.

Mr. Edward R. Russell was unanimously elected President for the next two Sessions.

* See page 209.

Dr. J. Campbell Brown communicated a brief paper on "Electric Lighting."

The following communications were then read :—

ON EUPHOBERIA AND PERIPATUS.

By the Rev. H. H. HIGGINS, M.A.

Missing links in the great catenary system of evolution come in very slowly, notwithstanding they have been profusely advertised as desiderata, with the proffer of a niche in the temple of scientific fame as a reward for the finder. Yet public confidence in the theory of development steadily increases, and extends far outside the professorial circle. Confirmatory evidence of a general character abounds; but facts, showing the derivation of a specific form from an ancestral type existing in a previous geological period, are rare; and we know how long Professor Huxley had to wait before he was able to cite even a single instance satisfactory to himself.

In 1871, when my attention was much occupied with making a collection of fossils from the coal-measures at Ravenhead, I was especially struck with the occurrence of fossil remains of no less than six of the great divisions of the animal kingdom—Pisces, Insecta, Myriapoda, Crustacea, Annelida, and Mollusca, all within a few yards of the same spot. It may be noticed that the sub-kingdoms not represented are those of lower organisation, Coelenterata and Protozoa, and that their absence may be due to circumstances unfavourable to their preservation in a recognisable form.

Of course, there was nothing new in finding such an assemblage; but to myself it was one thing to get up from a book the knowledge that it might be so, and quite another thing to pick up with one's own fingers the remains of insects, and the rest, from fragments of the old rock where, perhaps, millions of years ago, they had lived as neighbours. It was, moreover, exceedingly interesting to me to note the

great diversity of animal types existing where an extraordinary abundance of plant remains occurred, all belonging to a comparatively small section of the vegetable kingdom.

The fish remains, though found on the same bank, had been brought to the surface from a lower bed in the middle coal-measures.

Many of the fossils have been already described in various communications to other Societies; but hitherto I have said little about the solitary and somewhat obscure specimen of class Myriapoda found at Ravenhead. It was referred by myself at the time to genus *Euphoberia* of Woodward, but may belong to the allied genus *Xylobius*. Both the genera are known as fossils of the coal-measures.

The Hundred-legs, as they are popularly called, are divided into two groups, animal-feeders and vegetable-feeders; to the latter of which probably belonged the Ravenhead fossil. I found it at the base of a great hollow trunk of a Lepidodendron which, in a state of decay, had been filled with sandy mud. It might not, even now, have been worth while to call your attention to this obscure fossil, but for a remarkable investigation made by Mr. Moseley, of the Challenger Expedition, which seems to show that somewhere down amongst these creeping things with many legs, may possibly be found the link which joins the rest of the invertebrate animals with the vast class of insects.

It is strange that there should be more kinds of living things with six legs (*Insecta*) than there are of kinds with more than six legs, together with those that have fewer than that number, throwing the whole of the species of plants of all kinds into the bargain. That is, that insects should include about half the kinds of living things in the world. Yet this enormous Hexapod class (*Insecta*) touches the rest of the zoological series almost in a single point. Most of the orders of insects, with their many thousands of species, are

absolutely distinct, except amongst themselves. The small group of wingless insects, some of which are, I think, examples of degeneration, alone has affinities with forms outside the class. It may well be imagined how interesting a problem it is to naturalists to find some form prefiguring, without quite reaching, the insect type. Mr. Moseley thinks he has succeeded in doing this in his investigations of the structure of *Peripatus*, a form between a Myriapod and a Bristle-worm. A full account, with illustrative plates, may be found in the Transactions of the Royal Society for 1874; and a shorter notice in Mr. Moseley's delighful work, *Notes by a Naturalist on the Challenger*, 1879. It is of the nature of such observations to be in a great measure esoteric, by reason of inevitable technicalities; the result being that evolution is commonly regarded as a question of highly speculative philosophy, whilst it should rather be recognised as a more or less reasonable inference from the facts of Nature. It will be my endeavour very briefly to render at least *one point* in Mr. Moseley's interesting discovery intelligible to those who are not specialists.

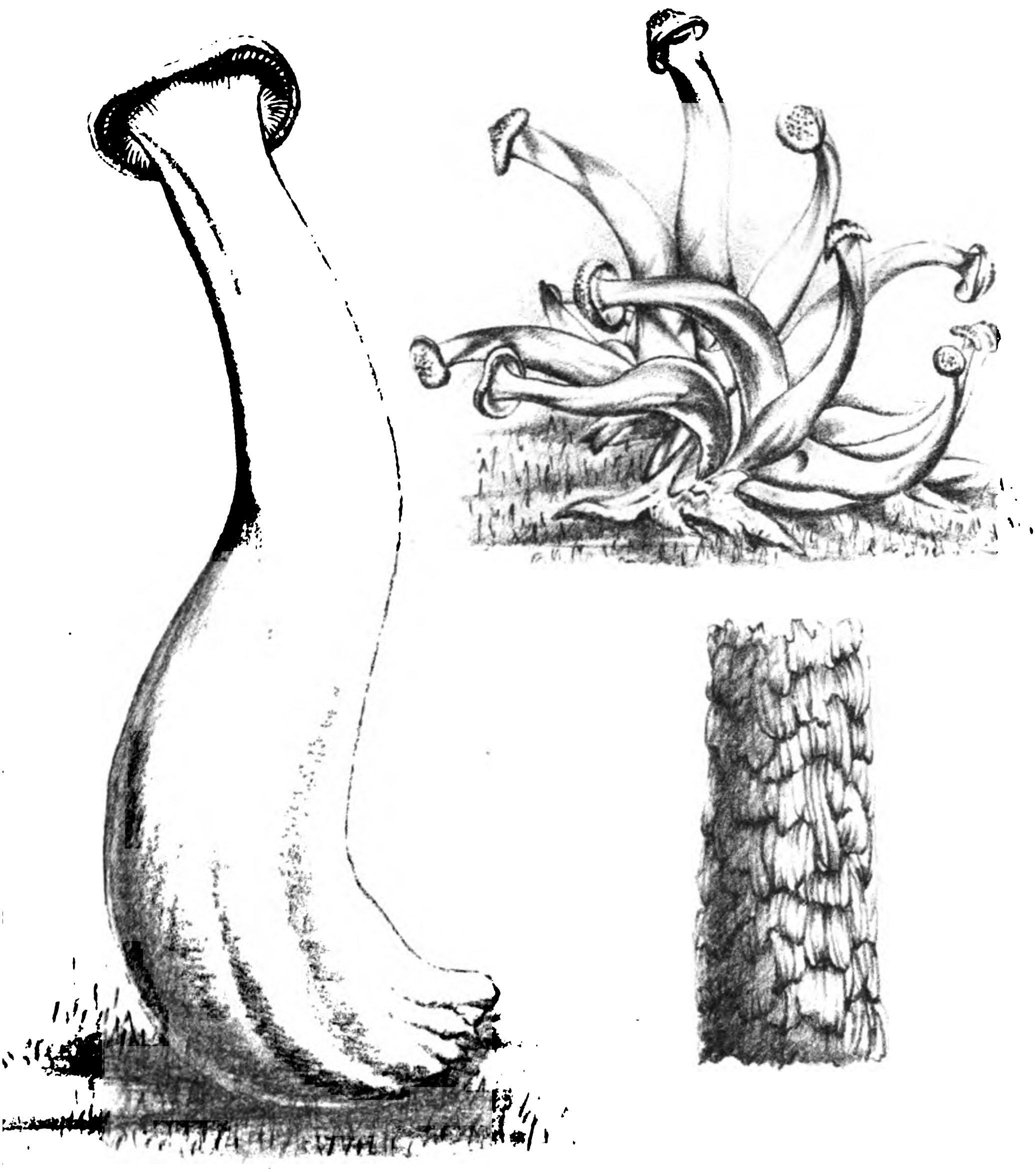
Amongst invertebrate animals with jointed limbs (*Arthropoda*), except the Crustacea, breathing is effected by a system of air-tubes, *tracheæ*, forming a united respiratory apparatus. Now, as these air-tubes do not exist at all in other sub-kingdoms, and as in all the known animals provided with them the air-tubes are found in a stage considerably advanced towards perfection, it was an enquiry of much interest, what would probably be the form in which the air-tubes would first make their appearance; and it was suggested that they would probably first occur as little detached sprays of tubes, each in communication with the outward air, and diffused generally over the surface of the animal, under the skin. But no such structure was known to exist in any animal. Some worms and leeches have, indeed, little

branched organs under the skin; but they are glands, not air-tubes.

A somewhat obscure animal had been found at the Cape of Good Hope and elsewhere, which had been examined and named *Peripatus*, and was pronounced to be a worm. Not satisfied with previous investigations, Mr. Moseley and his lamented coadjutor, the late Dr. Willemoes Suhm, on their arrival at the Cape, competed in friendly rivalry for the first possession and examination of the animal. Peripatus was, however, scarce and hard to find. The lot fell to Mr. Moseley; his microscope was expeditiously applied, and for the first time in the annals of science the little detached branching air-tubes, with their pearly lustre and spiral structure, were seen by him, thus verifying a scientific conjecture founded on the theory of development. The chemists are, I believe, quite accustomed to similar gratifications, but they are sufficiently rare to make them extremely acceptable to biologists.

But to return to our fossil. On the appearance of Mr. Moseley's book, I was much struck with the apparent resemblance between *Peripatus* and *Euphoberia*, and, in reply to a communication on the subject, Mr. Moseley thus writes:—"I should be very glad if it could be shown that any fossil Myriapods, as *Euphoberia*, were allied to *Peripatus*."

In conclusion, I may remark that Mr. Moseley's discovery, though a very gratifying one, goes but a little way towards ascertaining the developmental history of insects. Let it be fully conceded that *Peripatus* stands in ancestral relationship to class *Insecta*—let close affinity between *Peripatus* and *Euphoberia* also be conceded—that which seems to follow is the extreme antiquity of the form, even in the age of the coal-measures, when it coexisted with insects apparently as large and as well developed as they are now.



GROWTH OF AGARICUS (COLLYBIA) FUSIPES OF BULLIARD IN THE DARK.

PECULIAR GROWTH OF AGARICUS IN THE ABSENCE OF LIGHT.

By the Rev. H. H. HIGGINS, M.A.

Late in the autumn of 1878 my attention was called to a specimen of a Fungus of the mushroom tribe, allied to *Agaricus* (*Collybia*) *fusipes* of Bulliard, which had been found growing in an excavation under the floor of an iron-founder's shop in Lime Street. The hole, which was about sixteen inches square by thirty inches in depth, had been dug under a punch worked by steam, and was kept covered, except on rare occasions, by an iron plate, which totally excluded the light. Some time previously, the iron plate had been taken off, and the hole was described as being then nearly filled up by masses of the Fungus, which were cut away and removed. About six weeks after, the discovery of fresh masses of the Fungus led to my being induced to visit and examine the spot. The following points seemed to me to be of sufficient interest to be worth recording.

The hole was dug in the ordinary rubble of old foundations. No portions of timber or wood appeared in the walls of the excavation; but such materials might have existed a few inches deep in the very miscellaneous matrix on which the Fungus was growing. The place felt warm, and was quite dry. The surfaces of the few plants still vegetating in the hole were thickly beaded with drops of water, and the whole substance of the Fungus was highly turgid with excessive moisture, but was quite firm, and in a vigorously growing condition. Each stem terminated upwards in a mushroom-like head (*pileus*), with gills (*hymenium*) developed on its under side; but instead of attaining its ordinary diameter of several inches, each pileus was but little broader than the stem on which it was growing. In every case the upper surface of the pileus, which, in this species, is ordinarily quite smooth, was thickly beset with small definitely-shaped

tubercles. The specimen brought to me consisted of ten or twelve stems growing in a closely tufted manner. I have much pleasure in exhibiting a coloured drawing of the Fungus, as it was when first taken from the hole, executed by Mr. J. Chard, of the Liverpool Museum. The specimen itself is now before you, and you perceive that it has shrunk excessively in drying. The bundles of fibrillæ (*hyphæ*) constituting the stem, now stand out distinctly on the surface like cords or wires. They seem to appear, disappear, and reappear, like the withies in basket-work, or like the adventitious roots on the stem of a Tree-fern; or as may be seen in the strands of some patterns of telegraph cables. On close examination, however, and by the aid of cross sections, I find this curious appearance to be only the result of shrinking; for, on the convex side of a curved stem, the hyphæ are externally continuous from the base to the pileus.

As to the supply of pabulum, I conclude that some extensive deposit of vegetable and nitrogenous matter must have existed near the hole, favouring the growth of mycelium, the filaments of which had worked their way to the excavation. The comparatively warm temperature in which the Fungus was growing may account for a larger amount of watery vapour being present in the surrounding atmosphere; but how the plant contrived to appropriate so large a portion of it, and to condense it in drops upon its surface, whilst the sides and bottom of the hole were dry and almost dusty, I am not able to explain.

The great development of the stem, as compared with the dwindled pileus and hymenium, may be attributed to the absence of light. But by far the most interesting point was the occurrence on the upper surface of the pileus of tubercles, which were evidently continuations of the hyphæ of the stem. In the ordinary course of growth the hyphæ would, at a certain stage, have left the vertical, and assumed the

centrifugal or horizontal position, in developing the pileus and hymenium; but the conditions being unfavourable to the formation of reproductive organs, the amount of unexpended growing force caused the hyphæ to push their way right through the pileus, probably in the direction of some small chink admitting a faint glimmer of light, and possibly with the intention of forming a second pileus above the first, if they could reach a position more open to the light.

Such an application of unexpended energy is well known in phanerogamic plants. The most familiar instance which occurs to me may be found in certain forms of Polyanthus, in which a second corolla is formed, not through the replacement of anthers by petals, as in ordinary double flowers, but by the superfluity of petal-forming energy.

But in the case of the Fungus, the growth of the hyphæ through the atrophied pileus is even more remarkable, and approaches the result of instinct. Mr. Francis Darwin has written some interesting papers on instinct in plants, and has shown that the parallelism between plants and animals is, in many cases, very striking. I must admit that the tubercles on the pileus of the Fungus from the dark hole in Lime Street seem to me almost to suggest a vegetative effort in the hyphæ, which, if it could express itself in words, would say —"What is the use of setting to work to form spores down here in the dark; let us go up higher, and see if we can find more light."

Mr. Samuel Butler, who regards the activities of life as being directed by memory, and affirms that cells, animal or vegetable, always act as they did on the last occasion when they were under similiar conditions, would say that the Fungus grew as it had grown before under like circumstances. I do not recollect having met with a similar case. *Agaricus fusipes*, if it be that, is very rare near Liverpool. I met with it for the first time this season in Knowsley Park.

But, in fact, Fungi so highly differentiated as the *Agaricini* rarely grow in darkness.

It is needless for me to say that it is no capricious form. The veteran Mycologist, ELIAS FRIES, figures an Agariform Fungus, *Agaricus* (*Armillaria*) *denigratus*, not known as a British species, with a second pileus and stem growing out of the first; and he calls it a freak of nature, *Lusus naturæ*. But I think there is a more satisfactory way of accounting for the odd phenomenon.

The species of *Armillaria* often spring up very close together, and the surface of the pileus, in certain states of the weather, is very adhesive; the slime with which the pileus is covered being, in fact, almost glutinous. In the case figured by Fries, the pileus of a strong growing specimen had become firmly attached to the pileus of a weaker and more diminutive neighbour; and the stronger one, not being inclined, or rather, not being able, to wait for the little one, fairly tore it up by the roots, and hoisted it aloft topsy-turvy, stem uppermost! The substances of the two pilei appear to have coalesced.

HYDROCORALLINÆ.

BY THE REV. H. H. HIGGINS, M.A.

The great sub-kingdom of Polypes, *Cœlenterata*, is divided into two sections; in the former of which, *Hydrozoa*, the animals possess a body-cavity which is quite simple, like a pouch; whilst in the latter, *Actinozoa*, the body-cavity is divided into compartments by partitions, radiating like the spokes of a wheel.

For a long time it was thought that all the hydra-like polypes in the first section were small, as the Hydra itself, or as in the Zoophytes. Then it was found that in the Jelly-fish, the suspended part, *manubrium*, was a hydra-like polype, and that the great umbrella of jelly was a swimming

apparatus, carrying about the polype to get its food and to propagate its kind. So it was seen that the hydra-like polypes were not all of them by any means small things; but still it was thought they were all of them flabby, or soft, or, at all events, flexible, like the Zoophytes; and that they could not have hard, stony skeletons, such as the branching and rocky corals. This distinction also had to be given up, and the story of its fall is rather a curious one.

There is a coral known to seafaring men as Sea-ginger, growing often in immense clusters, and common in all hot seas. Now, it was quite certain that this coral was the skeleton of a vast assemblage of polypes; but nobody had seen them. It was, I believe, Professor Alexander Agassiz who first had a good sight of them, and he found that they were hydra-like polypes; but they were very small, and extremely shy of being looked at. My own best efforts to observe them were in vain, though I had the coral alive in aquaria for some time in the West Indies.

Mr. Moseley, one of the naturalists on board the Challenger, was enabled to examine a kind of Sea-ginger, *Millepora nodosa*, of which I exhibit a specimen. In this coral the polypes proved to be larger and less bashful; and his discovery of their true character is, perhaps, one of the most brilliant achievements in biology accomplished during the voyage of the Challenger.

The quasi individuals, for in some of these lower forms of life individuality is very promiscuous, are of two kinds. There is a larger central zoöid which is unbranched, short, and stout, and has a mouth and a body-cavity. Surrounding the central zoöid are five or more tall, slender, branched zoöids, which have neither mouth nor body-cavity: their office is that of purveyors; they capture small nutritious particles, and by bending themselves down, as a swan bends

its neck, they deliver the food to the central zoöid, which swallows it for the good of the community.

The tentacles of the common Hydra do much the same kind of thing; the chief point of interest in the Millepose coral being the admirably solid skeleton secreted, and the great differentiation of parts for special functions in so lowly a form of life. The stony corals formed by polypes like the Hydra, are now called *Hydrocorallinæ*, and include some of the most exquisite forms, combined with the most delicate and beautiful colours, to be found in the whole of the Coelenterate sub-kingdom.

The recent acquisition by the Liverpool Museum of some *Hydrocorallinæ* of altogether unusual beauty and perfection, has induced me to attempt to show, in a plain way, that they are something more than objects pretty to see. The specimens illustrate, probably, the highest point of development of which the Hydroid type is capable, and where the line stops short. They are of the type of the common Hydra of our ditches and ponds. It is not from amongst these elegant and highly ornate forms that further development proceeds, and that the higher group of corals with rayed polypes is derived. Mr. Wallace remarks that so perfect a structure as the eye has been developed on two or three distinct lines.

The *Hydrocorallinæ* are comparatively of recent origin, being, probably, not more ancient than the Tertiary period; whilst the corals of the rayed polypes are known from the Silurian. The lower type seems to spring from the higher, and not the higher from the lower; or the stocks may have been distinct from the time of the Graptolites in the Cambrian.

Mr. T. J. Moore exhibited the following drawings and recent additions to the Free Public Museum :—

A coloured drawing, by Mr. John Chard, Museum Draughtsman, taken from a specimen of the Dolphin (*Del-*

phinus delphis, Linnæus), stranded at New Brighton in February last; the skeleton of which had been purchased for the Museum. This Cetacean has not been previously recorded as occurring in the neighbourhood of Liverpool, and is an important addition to the local Fauna. The specimen would probably not have been captured, but that it had recently lost its tail, which had been completely and cleanly severed from the body, probably by the fan of some passing screw steamship, with which the creature had unwittingly come in contact.

A small drawing, by Commander W. E. Cookson, R.N., H.M.S. Eagle, stationed in the Mersey, of one of the remarkable Giant Tortoises, taken by him at the Galapagos Islands, viz., *Testudo Abingdonii*. Science is indebted to Commander Cookson for the first specimen of this species ever brought to Europe, as well as for examples of other species of these rapidly decreasing species, and for valuable information respecting them, as recorded in the *Proceedings of the Zoological Society of London*, 1876, pp. 520-526; and in Dr. Günther's Catalogue of *The Gigantic Land-Tortoises (living and extinct) in the Collection of the British Museum;* quarto, 1877.

A collection of Moa Bones (*Dinornis*), forming a nearly complete skeleton of one of these extinct gigantic birds of New Zealand, presented by Dr. Millen Coughtrey, Corresponding Member.

Mr. T. J. Moore then read the following communications recently received by him from Mr. E. Dukinfield Jones, Corresponding Member of the Society, and exhibited the beautiful drawings, as well as the specimens, mentioned therein; and expressed the hope that Mr. Jones would shortly send perfect specimens of all the other insects spoken of, in order that they may be identified.

"Sao Paulo, Brazil, 26*th January*, 1879.

"My dear Sir,—I have received your letter of Nov. 15th, and the copies of my paper on 'Experiments with Venomous Caterpillars.' The plate is beautifully executed, and it is a satisfaction to see one's work so excellently carried out. . . .

"This season does not appear to be nearly so good a one as the last. We have had unusually cold weather up to the end of December, and now the rain is excessive. Already thirteen inches this month! The wet, no doubt, must cause a great many specimens to perish.

"*Morpho Laertes* is just beginning. Last year I noticed specimens on January 1st. I have a number of the chrysalids, one of which has come out. A lady in Rio, who has a very extensive collection, pointed out to me that the females of *M. Laertes*, in São Paulo, are much more richly marbled on the underside than those of Rio de Janeiro. In the males there is not so much difference. Some of the females I obtained last year are very handsome.

"At the end of December I found a cluster of caterpillars of a *Papilio*, in the trunk of a Tangierine orange tree. There were about forty specimens in the cluster. The scent organs are very largely developed, and I observed that they had the power of flinging a tiny drop of colourless fluid on to any offending object. This fluid has a very disagreeable and pungent smell, and would no doubt prevent the caterpillar being eaten by any bird. But they seem to be very much attacked by an ichneumon fly. Out of seven chrysalids, only three have come to perfection. The odour of the caterpillars is so strong that I could smell them at a considerable distance from the tree.

"The butterflies have made their appearance, having been twenty-three days in the pupa state. It is a beautiful insect;

the anterior wings are black, shaded with grey, and the posterior black, with a pinkish-crimson spot, shot with purple. This makes thirty-eight species worked out from the caterpillar. I have a dozen chrysalids of a species of *Morpho*, which I am anxiously watching, hoping they will turn out *Achilles*.* In any case they are sure to be magnificent creatures, for they are very large and robust, and all the family of *Morphos* are lovely insects. I was fortunate enough to find a large cluster of the caterpillars, just ready to change, great stout fellows of a brick-red colour, with tufts of black and of white hairs, the black ones being barbed, and coming out if touched with the back of the hand, and causing great irritation. Before changing they turned completely green, which is a remarkable change from red. The chrysalis is a dull green, covered with a white bloom, that easily rubs off. The caterpillar emits a disagreeable choking odour when irritated, similar to that of *Morpho Laertes*. But it is quite distinct, and I could tell the two species with my eyes shut by the peculiar smell. This species feeds on a climbing plant (one of the *Bignoniaceæ ?*) while *M. Laertes* feeds on a papilionaceous tree.

"I think it is time I began to send you some of the results of my observations of the metamorphoses, and I will begin by a paper on that most interesting moth whose larva lives in the hammock-like case. The drawings, you will observe, are not properly finished; but I hope they will convey some idea of what the creature is like. The fact of the matter was, that after I had drawn the hammocks, I left the drawing to finish when I had more leisure; but, unfortunately, when I went to work again, I found the paper had got so mildewed that it was impossible to do anything with it. So I could only just outline the moth and leave the rest alone. If you place

* They proved to be a different species.—T. J. M.

the three pieces together, you will see what the drawing was intended to be. . . .

"Believe me,

"Yours sincerely,

"E. DUKINFIELD JONES.

"MR. THOS. J. MOORE,

"MUSEUM, LIVERPOOL.

"*1st February*, 1879.

"P.S.—Since writing the above, two more moths have arrived at perfection, bringing the list up to *forty species*. They both belong to the same genus as the venomous one with which I made the experiment (probably *Lagoa*). One of them is the curious hairy caterpillar, like a Skye terrier (No. 42), of which I sent you a rough sketch last April. The moth is beautifully marked, the veining of the wings being clear and striking. . . .

"A few days ago I found some young specimens of a spiny caterpillar (*Citheronia ?*), and I killed one by putting a drop of benzine on it. Another one, which was just about to change its skin, I also dropped benzine on. But it did not seem to affect it in any way. Next day I dropped some more on it. The day after I found it had changed its skin, eaten it, and half devoured the other caterpillar that I had killed with benzine!

"This caterpillar is remarkable for the great changes of colour from the young to the full-fed condition. At first it is black, with a brown mark in the middle, and the anterior segments are armed with curious long spines, with a crescent-shaped top. After the second (?) change the spines lose the crescent, but are very long and black. After the last change, the general colour is a smoky pink; the spines are nearly colourless and transparent. The colour then changes (without casting the skin) to a beautiful green; the spines become short and bright red, tipped with black.—E. D. J.

Fig 4.

E D JONES, DEL

HAMMOCK MOTH .. PEROPHORA SANGUINOLENTA, FELDER

"5th February.

"P.P.S.—Since writing the above I have had a visit from Capt. Eills, who very kindly offered to take charge of anything I wished to send you, so I have very hurriedly put up a few of my sketches, and also two adult specimens of the hammock-moth, two of the larvæ, one pupa, eggs, &c. . . .

"By next mail I will send you any observations I have to make on the sketches sent. I have not time now.—E. D. J."

NOTES ON THE VARIOUS STAGES OF THE "HAMMOCK MOTH."

BY E. DUKINFIELD JONES, C.E., CORRESPONDING MEMBER.

Perophora sanguinolenta, Felder, Voy. *Novara*, Lep. pl. 92, f. 4. FAM. *Labiocampidæ*.*

The caterpillars of this species were found in great quantities nearly full-fed at the end of December, 1877. They feed upon a shrub belonging to the Myrtaceæ, which grows in abundance on the low ground at each side of the River Tieté, at São Paulo.

The caterpillar lives in a hard strong case, which is, when the caterpillar is full-fed, about five centimetres (two inches) long, and fifteen millimetres (five-eighths of an inch) in diameter at the centre. The case is formed of the excrement of the caterpillar, bound together with silk and mucilage.

The case is enlarged, as the caterpillar grows, in the following manner:—The caterpillar starts at one end and attaches pieces of excrement in a saucer-like shape, fastening them together with silk and gum. The edges of the new work are gradually brought back to about two-thirds of the length of the case, and curled up more and more, till at last

* I am indebted to my brother, Mr. Frederic Moore, of the India Museum, for determining the specimens of the Hammock Moth, sent by Mr. E. D. Jones with this paper.—T. J. MOORE.

they meet overhead (Fig. 1), and then the arch is joined up all along till it is quite closed up to the old case. The portion inside the new work is then cut away, and the enlarged case is ready for the caterpillar to increase in size. It is a remarkable fact that the excrement is not cylindrical, as in most caterpillars, but flattened at the sides, so as to adapt it for building purposes.

I procured over a hundred specimens of the insect in various stages of advancement; some just forming the last increase to the case, some full-grown, some just turning, and some already in the pupa state.

The larva is of a dull brown, or sepia, the head and thoracic legs black, or nearly so. The thoracic segments, when the caterpillar is extended from the case (Fig. 2), are very slender, while the abdominal ones are puffed out. The abdominal legs are very slightly developed, and are quite incapable of grasping anything, though they hold very tightly on to the inside of the case.

When extended and moving the body about in search of food, or for a point to fix its lines to, the resemblance to a leech is remarkable.

The first proceeding when a case is placed amongst the leaves of the shrub, after being pulled off, is for the caterpillar to fix the "hammock" by silken threads from various points to several places in the surrounding foliage. This is done by stretching out till the first pair of feet can grasp a leaf; the silk is then attached first to this, and then to the hammock. The mouth is now moved up and down this thread, adding one more filament each time, till a sufficient thickness is attained. I saw one individual spin *thirty-six threads to make one cord.* Then another cord is fixed to an adjoining leaf in the same way, and so on till the caterpillar is satisfied that that end is secure. The number of cords is usually from two to four. Then he turns round in the case

and puts his head out at the other end, and fixes it in the same way (Fig. 3). When both ends are secure, he goes to work and eats all the leaves within his range. When moving from one place to another, I have observed that a new line is always fixed in the direction of the desired motion before the old one in the rear is cut away. When the new line is satisfactorily fixed, the old line is cut and *swallowed by the caterpillar*, being devoured just as one eats a piece of celery or a radish.

The movements of the caterpillar are remarkably quick, the slightest alarm while it is extended causing it to dart back into the case. When fully extended the full-grown larva is as much as seven centimetres in length, though when retracted within the case it is not much over three centimetres. Though perfectly free within the case, and capable of turning round so that the head protrudes from either end indiscriminately in a marvellously short time, I have never seen the caterpillar entirely leave the case.

Examination with a lens shows the body to be covered with small bony plates, evidently designed to protect the insect from the friction of constantly pushing in and out of the small openings in the case.

An instance of the quick movements of the caterpillar is seen in the way it gets rid of the excrement if the hammock happens to be in such a position that it does not fall out of its own accord. The last segment is drawn up a little, and at the same time depressed, then it suddenly "lets go," and the movement literally kicks the offending matter out of the case.

A curious habit of this caterpillar is observed in its eating. A leaf is often cut off near the stem, and the piece thus cut off is held by the feet while the caterpillar devours it, using the feet like paws (Fig. 4).

Another habit is that of making a low intermittent

musical sound when the hammock is held in the hand or the caterpillar otherwise annoyed. The sound is so faint that it can scarcely be heard unless the case is held close to the ear; but the vibrations can be distinctly felt by the fingers. Another way of showing its disapproval is by wagging its head from side to side and pulling it with a jerk into the case, slowly protruding it, jerking it in again, and so on, the action being repeated several times. When at rest, the head of the caterpillar just appears outside one of the openings.

When full-fed, one end of the case is firmly fixed to a twig in an upright, or nearly upright, position, so that the upper curved end protects the opening from rain (Fig. 5), and, in addition to this, the opening is partially closed with a thin web. The upper end is also secured by guys to the surrounding twigs. The caterpillar remains in an active condition for several weeks after fixing the case, during which time it is employed (at night) in strengthening the case with silk, covering all inequalities till the separate pieces of excrement are quite indistinguishable.

The caterpillar is active at night only, eating, moving about, increasing the case, etc., only after dusk. During the daytime it remains dormant in the hammock.

On January 3rd, 1878, one of my specimens fell out of its case that was already permanently fixed, on to the top of my microscope box, and a few days afterwards it fixed a couple of lines from the box to the handle, evidently feeling obliged to put the guys somewhere, and not finding its own case to fix them to. After this it remained quiet, most of its time being spent with its head bent round against the body. On February 1st it died, not having strength to change to the pupa state.

In this species the case is invariably fixed *above* the twig, that is to say, the *lower* end of the case is attached; but in

another species, closely allied, the *upper* end is fixed to the twig, so that it hangs *below* the point of support.

By January 20th nearly all my specimens were full-fed.

On March 15th, the first moth (female) made its appearance, the larva of which was full-fed January 6th, and which changed to the pupa state January 22nd. After emerging, the moth remained for several days in the curious position shown in Fig. 6.

On June 7th, a second specimen, also a female, came out, behaving in the same manner as the former, and one whole day she passed wrong side up (Fig. 7). On the evening of June 17th she flew away.

But the bulk of the moths did not appear till the beginning of October, and they continued to appear till the middle of November.

It is a remarkable fact that the earlier specimens were females and the later ones mostly males. This is very unusual in Lepidoptera. The females alone behaved in the curious way mentioned above, the males always flying away the evening after they emerged from the pupa.

Although I tried to obtain fertile eggs, I was unsuccessful. Several of the moths laid eggs, but none of these produced caterpillars.

Several times male specimens entered my room while the females were apparently awaiting impregnation, but in no case did I observe any connection of the sexes.

PAPERS READ DURING SESSION.

NATURE OF INFECTIOUS MIASMS.

LIQUID. GASEOUS.

All soluble, chemical inorganic and organic poisons, venoms and secretions—not living.

SOLID.

Act not in proportion to quantity.

FERMENTS.

CHEMICAL.

Emulsin.
Diastase.
Myricin.
Ptyalin.
Pepsin, &c.

ORG.

Septic or
Alc

TIAL BIONS.

PARASITIC GERMS.

MORPHOLOGICALLY SPECIFIC PARASITIC DISEASES.

Entozoal Diseases.
Scabies.
Tinea tonsurans.
" circinata.
" favosa.
Trichinous Disease.
Fungous foot.
Endemic Dysentery of Egypt and the Cape.
Chylosuria and Elephantiasis, &c.

PHYSIOLOGICAL
PARASITIC I

Splenic Fever?
Relapsing Feve
Pneumo-enterit

GRAFT-GERMS, acting by { Simple Grafting, Conjugation? Rejuvenescence?

VEGETABLE.

SECRETIONS AND PARTIAL BIONS.

HEALTHY.

Pollen of the Grasses, causing Hay Fever.

DISEASED.

Malaria, causing Intermittent and Remittent Fevers.

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Chemical Septic Products

ON THE GERM THEORIES OF INFECTIOUS DISEASES.

By JOHN J. DRYSDALE, M.D., M.R.C.S.

The "pestilence that walketh in darkness" has from the earliest times affected so profoundly not only the happiness of families, but the wealth of nations, and even the course of civilisation, that it may be deemed a fit subject to be brought before a non-medical Society. I hope that the bearing of such inflictions on human affairs may be also considered of a sufficiently general nature to allow its being taken as the topic of the Opening Address of the Session.

When we consider the awful mortality of the great epidemics recorded in history — the Black Death of the fourteenth century having, for example, swept off one-quarter of the population of the old world in four years — and the almost total impotence of medicine for direct cure, we may indeed consider this a question more for statesmen and governing bodies than for physicians. Nevertheless, it is necessary that the efforts of the former should be guided by such knowledge of the nature and causes of these diseases as the science of the day can afford. Nor is such knowledge less to be desired for the people in general in order to counteract the baneful effects of ignorance and prejudice. It is a fact that, from the time of Thucydides down to the outbreak of the cholera in our own day, in all severe epidemics a false suspicion has prevailed that the wells or provisions were poisoned by supposed public enemies. To this groundless suspicion thousands of lives have been sacrificed, and it was the cause of the fearful persecution of the Jews in the fourteenth century. The simple knowledge of the fact of the universal prevalence of this suspicion, and, still more, the knowledge which medical science can now give with

certainty that no such poisons exist, ought to go far to prevent such aggravations of natural calamities for the future. And let not people fondly imagine that the days of national epidemics are over. On the contrary, there has been a constant succession of greater and lesser epidemics since the beginning of history, and the immunity of any generation from the greater plagues may be merely an interruption of the course liable to terminate any year by a fresh outbreak of some old or a quite new plague. For instance, the memory of the Sweating Sickness of 1485 was obliterated by the Plague of London, in 1499, but the former returned again unaltered in 1506; and again a third, fourth, and fifth time during the first half of the sixteenth century. Diphtheria has also reappeared again and again after being forgotten in intermediate generations, as also many varieties of spotted and typhous fevers and numerous other diseases. The subject is thus one of universal and abiding interest and concern to us all, so, without further preface, I will proceed to consider the light that may be thrown on these mysterious scourges of humanity by the so-called germ theories of which so much has been heard of late.

§ 1. Let us restrict our attention to those diseases the material exciting causes of which are termed, generically, miasms. Following a recent writer,* diseases arising from miasms may be divided into the miasmatic simple, the contagious, and those which partake of both characters, and hence called miasmatic-contagious. 1st. The contagious diseases arise from a contagious miasm or *contagium*, or specific excitant of disease, which is reproduced in the organism suffering from the specific disease. Under this head come smallpox, measles, scarlet fever, typhus, plague, glanders, &c. 2nd. Under the term miasmatic are comprehended malarious diseases, viz., the intermittent and

* Liebermeister, in *Ziemssen* I., p. 25.

remittent marsh fevers. Here the poison develops itself externally to the body, and is not reproduced therein so as to affect other men from thence, nor is it excreted thence to propagate itself in any other way. 3rd. The miasmatic-contagious comprehend cholera, typhoid, dysentery, and probably some others; here the disease is not readily, if at all, transmissible from person to person; nevertheless, these diseases never originate spontaneously or from purely malarious influences, but always after some person affected with them has been in the neighbourhood; so it is supposed the secretions from infected persons undergo development in favourable media out of the body. In other words, the reproduction of the miasm is partially performed out of the body.

§ 2. What is the intimate nature of this miasm or infectious matter? In the first place, as regards its physical state, it has been determined with respect to the vaccine and some other animal poisons, and is almost certain with the rest, that the specific power does not reside in anything which is gaseous, or liquid, or capable of solution, or diffusible from the medium in which it is contained.* Thus when we hear of sewage or paludal liquids or gases spoken of as the exciting causes of infectious diseases, it is to be understood that the true specific matter is a solid merely suspended in the liquid or gas. This at once cuts off a large number of both inorganic and organic substances from the category of possible causes of the specific disease. [See diagram]. Next

*Dr. Lionel Beale first attributed the infective properties of vaccine and other contagious diseases exclusively to solid matter, and this was experimentally demonstrated afterwards, first by Chauveau and then by Dr. B. Sanderson, by the method of diffusion. Filtration was ineffectual for separating the extremely minute particles in which the contagion resides, from the matrix fluid. Chauveau found the same principle to apply to variola, pleuro-pneumonia, glanders, and sheep-pox. The experiments with the vaccine matter have been recently repeated with greater care and detail by Drs. Braidwood and Vacher, of Birkenhead, who have proved that the liquid diffused out from vaccine matter is totally devoid of infective power.

is the distinguishing mark that they act independently of the quantity introduced into the body. This again cuts off all inorganic and organic stimuli and natural secretions not already disqualified by their liquid or gaseous nature, and leaves only the ferments and the contagia.

§ 3. Now, there are two distinct kinds of ferments, both of which may be said to display the last character, viz., the chemical ferments which catalytically excite an indefinite amount of change in other bodies without being themselves decomposed in the process; and the organised ferments which produce changes in virtue of their vital activity and growth as living organisms. The application of the same word, fermentation, to these different processes is one cause of the confusion in which the so-called germ-theory is involved, and which can only be avoided by keeping in mind the cardinal distinction between them, which is, that the chemical ferments, besides being soluble, and acting almost instantaneously at a very wide range of temperature, are *not reproduced* during their activity, whereas the organised ferments are reproduced therein.

§ 4. Now, although all living matter is particulate, and all contagia may be assumed to be particulate, and nothing reproduces itself except living matter, yet it does not follow that contagia must necessarily be living. For it may be that certain non-living morbid secretions may simply be capable of exciting in other persons a similar morbid secretion as specific stimuli not containing in their own nature, as living matter, the explanation of their reproduction. This would be simply to state the facts of contagion in the sense of its being a non-parasitic pathological phenomenon without any attempt at explanation. But, especially considering the minimal dose, there are good grounds now for looking for the explanation in the hypothesis of the living nature of the contagion itself. Granting, therefore, the possibility of this,

we are now by the above process of exclusion restricted to three known substances:—1st, parasites, already known as such; 2nd, the organised ferments; 3rd, portions of altered protoplasm, or living matter capable of transplantation and subsequent growth in the bodies of other persons; here called partial bions or graft-germs. Now, as the organised ferments are independent animal and vegetable beings, with their proper life history and mode of reproduction, they would necessarily come into the category of parasites if capable of running their course within the higher animals. The exciting causes of infectious disease is thus narrowed into two categories, viz., Parasitic-germs and Graft-germs.* [See diagram]. An immense step is thus made in unveiling

* It will clear up the subject amazingly if we set aside the questions of fermentation and spontaneous generation from all connection with infectious diseases. The superficial resemblance between the specific fevers and the process of fermentation is false and misleading, and it is unfortunate that the name of Zymotic should be sanctioned by authority as applied to those diseases. The true chemical ferments are recognised as agents which break up, with or without combination with oxygen, dead chemical matters by a purely chemical or non-vital process. There is no proof or probability that any chemical agent acts or could act thus on the living tissues or blood in the production of disease. And the sole analogy between the action of a contagious miasm and a chemical ferment is the circumstance of their both acting in minimal dose. From very different causes however; the organised ferment reproduces itself, and is thus multiplied indefinitely, while the chemical ferment simply acts over and over again without addition of new particles, and hence the analogy with a contagious miasm quite fails. There is a fallacy in the common mode of comparing the action of a chemical ferment to disease. For example, it is said, a single drop of septicemic blood introduced into the blood of a healthy animal acts like a ferment which, without being itself consumed, alters the whole blood and kills the animal. Again, a drop of the blood of this last animal (containing thus a mere fraction of the original drop) may alter the whole blood of a second animal and kill it. And so on indefinitely, always because an indefinite quantity of blood can be split up catalytically by the ferment, in however small a dose, seeing that it is not consumed in the process. This mode of statement involves several assumptions, and is contrary to the facts. For the natural ferments require a certain degree of concentration, and will not convert an unlimited quantity, and are slowly consumed or absorbed in the process, thus requiring renewal by secretion. If the second

the mystery which has hitherto enveloped the mode of propagation of infectious diseases. For such germs being exceedingly minute, in fact, ultra-microscopic, it is easy to see how they can be spread abroad unsuspected in every variety of vehicle, and their power of survival, as well as their liability to destruction, corresponds accurately to what is known in these respects of the fomites of contagia. Their conveyance by solids and liquids presents no difficulties, but until lately it was not possible to trace them in the air, and, accordingly, numerous telluric and imponderable influences were imagined as the cause of the origin and spread of infectious diseases. But it has been demonstrated by the admirable experiments of Tyndall that all ordinary air contains ultra-microscopic

and succeeding generations of the poisoning were really caused by fractions of the original drop, the disease would be gradually slower and less virulent in its progress, whereas the exact contrary is the case. Besides, the known chemical ferments can hardly be called poisons, and even if injected into the blood would not be injurious except in far greater quantity than the contagia require; and therefore the law of minimal doses does not apply, while any injurious effect they may thus have is no doubt solely that of noxious foreign matters, of which any considerable quantity of any kind is injurious thus introduced. There is no proof whatever that they act as ferments when thus hurtful, and to assume that the contagia are chemical ferments of an unknown nature which may so act on the non-living part of the blood, is simply a gratuitous hypothesis. Thus, while failing to account for the cardinal phenomenon of multiplication of the contagion, the chemical ferment theory fails equally to account for the immediate operation of animal poisons.

On the other hand, the so-called organised ferments perfectly meet the cardinal point of reproduction; but even supposing they are proved to be the cause of contagious diseases, how far can this operation be compared to their effects on dead organic matter known as fermentation and putrefaction? In these processes it is obvious the fermentive and putrefactive organisms may act in two ways:—1st. They may secrete a chemical ferment which may do all the work chemically; or, 2nd, they may, as a vital process, consume the fermentable substance as other living creatures do pabulum, and the products, viz., alcohol, carbonic acid, ammonia, succinic acid, &c., may simply correspond to the urea carbonic acid, water, &c., given off by the higher animals. Now, it is proved that yeast does secrete such a chemical ferment, and it is highly probable that the bacteria do so also, and it may be accepted that the living ferments operate in both these

organic matter; and further, by the method of subsidence in these experiments these matters are proved to be particulate and ponderable, and to contain among them living germs of a great variety of septic and alcoholic ferment-organisms and monads, differing according to the locality of the air tested. Thus a perfect cloud of noxious living matters may be wafted hither and thither in air, apparently quite pure and transparent. While we accept the fact that organic matters are contained in all air, however apparently pure, and what is also the fact that among these organic matters a great variety of protozoal germs are included, it does not follow that there are no other organic and even organised matters which may play the part of contagia. Nevertheless, as we are all liable

ways, although it is not settled yet to what extent each contributes to the final result. It is, however, by far the most probable that the chemical effect of a secretion is quite subordinate in the result as a whole, and is confined to altering the dead matter so as to be more suitable for pabulum; that, for example, a secretion from the bacteria acts on the nitrogenous matter somewhat as the gastric juice does on the food of higher animals. The bacteria, in fact, having no intestinal cavity, live as it were in their own gastric juice, and therefore require a certain stillness or stagnation in the liquid medium in order to thrive. The great bulk of the action of ferment and putrefactive organisms is thus simply that of devouring dead organic matter. How, then, do they act on the living body? Assuredly not by the chemical ferment, for that can only break up definite dead chemical compounds, and not the living matter itself; while the chemical ferment and the other products of bacterial life must act on the living matter as more or less noxious stimuli, and thus produce disease long before they could exert any notable changes on the non-living portions of living bodies as chemical agents. Hence the signs of action of saprophytes in the living body, except quite locally, are not signs of putrefaction, but signs of disease. The chemical products of the putrefactive organism thus acting as noxious stimuli are decomposed or eliminated long before they can act as purely catalytic ferments. On the other hand, the living organisms themselves, yeast and bacteria, cannot devour living matter—no pabulum is living—they must first kill it, and then devour. That is to say, unless they are themselves first killed and devoured by the living bioplasts, which is the case in health with respect to the large majority of such organisms introduced (or their germs) into the larger animals and plants. (See § 12. Vital resistance.) There are some exceptions in which the juices of the host and its living matter are either favourable to or tolerate the sub-

to be more impressed with what we see than by what we don't see, and as bacteria are readily demonstrated in a test tube with proper pabulum, while it is impossible so to exhibit, say the smallpox, in a like way, and as some contagious specific diseases are certainly attended with the growth of microphytes in the blood and other parts, it has been concluded somewhat hastily that the growth and development of these germs as parasites is the cause of specific diseases in general. In recent times the chief patrons of this theory, following Pasteur and the distinguished botanist, F. Cohn, of Breslau, have been natural historians and physicists, while in the medical profession, which is naturally more familiar with the clinical facts of disease, its adherents have hitherto been

ordinate organism. In such case the latter lives, and is called a parasite, and when, in certain circumstances, saprophytes survive in the higher animals, it must be as parasites; and, like them, they may produce disease by competing with the host for pabulum, by mechanical obstruction, by irritation, and by the formation of noxious products, all of which cause disease, but which together do not constitute what is known as fermentation and putrefaction of dead matters, although the mere life of the saprophyte is the same. The question of spontaneous generation is also here an idle one in these diseases. For they would still act as parasites whether sprung from dead matter or heterogenetically descended from the bioplasts of the host. And if they came into being *de novo* in the diseased body-fluids, it is beyond all credibility that they should always assume the exact form of those organisms whose access from without is so easy to account for. (§ 11.) In Dr. Bastian's paper, in the *Journal of the Linnæan Society*, for October, 1877, and May, 1878, he sums up against the germ-theory as it is presented by Dr. Wm. Roberts, and substantially is in accordance with Dr. Beale. The discrepancies still remaining between them could be reconciled, I think, by the additions here made by me to Dr. Beale's theory, if the questions of fermentation and spontaneous generation were put aside. But Dr. Bastian unfortunately still continues to mix them up with the pathology of infectious diseases, and thereby much weakens the influence of his deservedly great authority as a pathologist against the exclusively parasitic theories of Pasteur and Cohn. It is quite allowable to contend for the hypothesis of spontaneous generation as a thesis in general biology, although the majority may be as yet unconvinced by him; yet what good purpose can it serve to bring it into our subject, when he admits the origin of contagious diseases *de novo* by what is substantially the same as Beale's degradation of protoplasm into disease-germs, or what are here called partial bions?

in the minority. But recently the distinguished clinical pathologist, Dr. W. Roberts, of Manchester, in his admirable Address on this subject before the British Medical Association, in 1877, has pronounced in favour of the parasitic-germ theory. And the foremost of our experimental pathologists, Dr. Burdon Sanderson, speaks, although with much hesitation, also in its favour. In the attempt to unravel the complexities in which the parasitic-germ theory of infectious diseases is involved, let us shortly trace its history, for it is by no means quite new, as some imagine. The doctrine of *contagium animatum*, which was even then old, was revived in the last century by Kircher, it was partially sanctioned by Linnæus, and early in this century was supported by more specific facts brought forward by Schönlein, Langenbeck, Sir Henry Holland, and others. But the most complete statement was given first by Henle, in 1840, and again in his *Rationelle Pathologie*, in 1853. Since then little has been added to the theoretical aspect of the question, although an enormous addition has been made to the known facts. The fundamental points of the theory are shortly these. We may safely hold that a parasite is the cause of all those symptoms which are brought on by the introduction of the parasite and disappear with the removal of it. Thus parasitic diseases may be called contagious, if the parasite is transferred from one person to another, and the parasite itself may with propriety be called the contagium. Now, as Henle says, it certainly sounds ridiculous, with our usual ideas of the nature of miasms, to speak of an eight-footed or a two-inch long contagium ; but, on the other hand, is it not a mere play upon words to say of the itch that it is not contagious, since it is discovered to depend upon the transference of the *Acarus scabiei?* So it is quite legitimate to say that, if in any recognised contagious diseases we find the exciting cause to reside in a parasite, we have explained the contagious process in such diseases.

And if the same holds good in all, we must allow that the parasitic theory explains contagious diseases in general. All depends upon the facts. The simple statement that a particular disease is coincident with the presence of foreign organisms, or even of a particular parasite, covers many fallacious inferences, for their presence may be secondary or accidental. The subject must therefore be followed out in detail.

§ 5. First take as the starting-point the entozoa, commonly called worms, the old-established typical parasites. Here, if the symptoms displayed by the host are to be called a disease at all, it is one certainly dependent on the presence of living beings, not produced spontaneously, nor by heterogenetic descent from the host, but which are distinct animals with, for the most part, a known life-history. The symptoms do not at all resemble those of the specific infectious diseases, and seem to depend on simple irritation and the abstraction of nutriment. But there are here already some analogies between the two, for the relationship between the parasite and the host is very close. Not only almost each species, animal and vegetable, has its proper parasite, but even different varieties or races of the same species have different and exclusive parasites, just as the specific diseases are confined to one or few species. Also, there is an indirect contagiousness, in that one stage of the life cycle of the entozoa is passed in a different host, just as in the miasmatic-contagious diseases morbid matter must pass out of the body of the patient and undergo some change outside before it can infect another person. They also resemble the infectious diseases in having a specific habitat; for of the entozoa some inhabit the stomach, some the liver, others again the large intestines, the kidneys, &c., just as smallpox attacks the skin, scarlet fever the throat, &c.

§ 6. We now pass to those affections which have been

long known as contagious and infectious diseases, and which have been more recently discovered to depend on the presence of parasites. Of these scabies, or the itch, was proved about fifty years ago to depend on the presence of the *Acarus scabiei*, or itch mite. Then, about thirty years ago, the various forms of ring-worm were traced to the presence of one or more species of fungi, from the transplantation of which, or the spores, the propagation of the disease depends. Within the last twenty years the list of epidemic and contagious diseases traced to animal and vegetable parasites has increased rapidly, and, if we include those of the lower animals and of plants, is now very large. It is sufficient to name as examples the potatoe disease as depending on the *Peronospera infestans;* the opium-blight, on the *P-arborescens;* the ergot of rye, on the *claviceps purpurea;* the grape vine disease, and a host of others among plants on well-described parasites; the fungoid diseases of silk-worms and other insects. What more immediately interests us is the tracing of internal diseases in the human species to the presence of parasites, as shown, for example, in the remarkable history of the discovery of the *Trichina spiralis*, or flesh-worm. The existence of this worm has been recognised for some years, but its connection with specific states of disease was hardly suspected till the simultaneous occurrence of a number of fatal cases of an unknown disease was traced to its agency. In 1863, in a small town in Prussia, occurred one of the most striking instances. After a public banquet about one hundred persons were struck down with disease, which proved fatal in a large number. The symptoms were great lassitude and depression of body and mind, complete loss of appetite, sleeplessness, then fever closely resembling some of the specific fevers such as typhoid; then excruciating pains in the muscles, especially of the extremities, and contraction of the knees and elbows, which could not be

extended for extreme pain; œdema of the eyelids and legs, difficulty of moving the tongue, profuse clammy perspirations, inflammation of the lungs, exhaustion, unconsciousness, and death. After death numberless living trichinæ were found in all the striated muscles, including those of the heart, some straight and some coiled, in all different stages of development. The parasite is bisexual, producing its young alive in the mucus of the intestines, in which it lives and moves freely; from thence the immature forms bore their way into the muscles, wherein they become encapsuled for a longer or shorter time, but may resume their activity and go through their complete stages and propagate again in the intestines. The whole process may be gone through in three to four weeks. The discovery of this horrible parasitic disease produced a profound sensation in all civilised countries, and it became evident that it could be nothing new, but an explanation was merely given of various anomalous epidemic and solitary cases of disease hitherto set down as typhoid or unknown forms of fever. It afforded, also, a good example of the ultimate tendency of the reduction of disease to parasitic exciting causes, viz., that for the protection of society against such diseases we must rely on police regulations for destruction of the sources, rather than on medicine, for in this case the latter was powerless to find a remedy. And in all such cases where the whole tissues or the blood are pervaded by innumerable microscopic organisms, it is hardly to be expected that we shall find substances which shall be poisons to these low creatures and at the same time harmless to the infinitely higher organisation of the host.

Another parasitic disease may be noticed derived from the vegetable kingdom, viz., the "fungous-foot" or "madura-foot" of India.

In this disease the spores of a mucedinous fungus penetrate the skin of the naked feet of the natives through small

accidental cracks or abrasions. These being capable, like true parasites, of living in the healthy fluids and tissues, grow rapidly and, with the tremendous molecular force of growing organisms, bore their way even into the bones, causing destruction of them and of the soft parts, with suppuration and wasting fever, so that death is only averted by amputation of the limb. Specimens of this fungus sent home to Mr. Berkeley were cultivated by him, and identified with the genus *Chionyphe*, and named by him, after the discoverer of the disease, *Chionyphe Carteri.* We have here, therefore, an example of a true parasitic disease, and one of peculiar interest, as it has been supposed to throw light on the nature of hospital gangrene, which is the scourge of military hospitals. Another disease traced to a parasite, this time animal, is the endemic dysentery of Egypt, which has been found to depend on the presence of a fluke-like worm, called the *Bilharzii hœmatobium.* Finally, we may note the more recent discovery of Dr. Lewis, of Calcutta, that the disease of the kidney, called Chyluria, and certain forms of Elephantiasis (a kind of leprosy), depend upon the presence of the *Filaria sanguinis,* a parasite which inhabits the blood-vessels. And here we may notice the still more recent discovery of Dr. Manson, of China, as throwing light on the mode of communication of infectious diseases, viz., that these worms are actually conveyed to men or animals by mosquitoes, which suck up the small worm with the blood of their victims, and thus transfer them to other living creatures.*

§ 7. The above are certainly proofs of the dependence of certain diseases, hitherto ranked among the miasmatic and contagious, on the presence of parasitic animal and vegetable organisms. So far, therefore, such a class of diseases exists.

* It is possible that we have here an explanation of the destructive power of the Tsetse fly, for it may be the intermediate host of some similar blood-parasite; or it may be the carrier of some infective poison. It is highly improbable that any mere poison or venom should exist so powerful as to cause the death of a large animal in such small dose.

But in all these cases the parasites are tolerably large and well-defined morphologically specific organisms; and the diseases themselves are comparatively rare, and differ so considerably from the common specific and infectious diseases, that it is only by somewhat straining the definition that they can be brought within the class. Are there examples among the true specific forms, such as measles, scarlet-fever, typhus, smallpox, &c., in which the universal presence of a special parasitic organism can be shown? The answer can now be given *primâ facie* in the affirmative in respect to two human diseases, viz., the splenic fever or anthrax, or malignant pustule of cattle and men; and the relapsing fever of men.

The anthrax, or malignant pustule, is a disease of extreme virulence and fatality both in cattle and in men, and is extremely contagious, so that a drop of the blood of an infected animal falling upon any uncovered part of the skin, even if unbroken, will produce the characteristic boil, followed by speedy infection of the whole blood. The course of the disease is extremely rapid, proving fatal in a few hours in some cases, and in most within a day or two; the symptoms being general disturbance, shivers, followed by febrile heat, debility, muscular twitches; then convulsions, hæmorrhages, and total collapse, with coldness and inability to move, difficult breathing, and death. In this fearful disease bacterial organisms were discovered in the blood by Davaine, about twenty-five years ago, and they were seen at different intervals since. Still their presence for long was not looked upon as an essential feature in the disease, and even in 1866 no mention is made of them in Aitkin's text-book of Medicine. Within the last eight or ten years, however, proofs have been gradually accumulating of the causal connection of this bacterium with the disease, and the observations of Dr. Koch, in 1876, are generally considered to amount to

positive demonstration. The facts are, that the blood is always found to contain an abundance of rod-bacteria, supposed by Davaine originally to constitute a distinct species, and, therefore, named *Bacteridia*, but which are pronounced by F. Cohn not to be distinguished morphologically from the *Bacillus subtilis* of the butyric fermentation, and, therefore, called by him *Bacillus anthracis*. The mode of action of the contagium is peculiar; the actual contact of the blood or exudations of a diseased animal infects another with certainty, but "animals placed in the closest proximity to the diseased ones, and placed in the most favourable circumstances for infection through the air, are not infected." (B. Sanderson.) The infective power of the blood is transitory, and is lost on the appearance of ordinary putrefaction, and it cannot be kept for more than a week generally, or at most five weeks, without losing its activity. Nevertheless, it is a fact that the contagion can exist in a persistent form, and lurk about stables and sheds for months, and even years, and can be transported across the Atlantic in hair and wool, thus infecting by air-borne dust. The blood, while capable of infecting, always contains the above bacilli, but when filtered through porcelain is no longer poisonous. The explanation of these facts is given by the experiments of Dr. Koch, since confirmed by those of Dr. Ewart, of University College, London.* It was found that the bacilli, at the height of the disease, are still growing and immature, and if such blood is quickly dried in small portions, or undergoes ordinary putrefaction, the bacilli perish, and with them the power of infection. But if a drop of the fresh blood, with living

* *Lecture on the Germ Theory*, by Dr. Burden Sanderson, 1878. Dr. Ewart has since published his results in the *Quarterly Microscopical Journal*, April, 1878. He finds that the rods are not motionless, as stated by Davaine. The formation of spores requires a moist state and a temperature between 28 and 33 C; and that it took place as well after death and out of the body. A heat of 37 C prevents the germination of the bacilli.

bacilli, is placed in serum at the temperature of the body, the bacilli soon begin to grow enormously in length, become studded with bright oval dots, and finally break up, leaving those dots, which are in reality spores, possessed of immense powers of resistance, and capable of germination after drying and passing through numberless vicissitudes. The same formation of spores may take place in larger masses of spleen or blood slowly dried. Thus are explained the fugitive and the persistent forms of the contagium—the one depending on the living bacillus, and the other on the spores. The reason why the infective power of the living blood is speedily lost is that the bacilli are propagated therein solely by fissiparous generation; and it is only in the blood of the dead animal, or in suitable dead nutriment, that the formation of spores takes place. Koch then proved by observation that these spores reproduce the rod-bacilli. Next, by experiment, he showed that these bacilli from cultivated spores had the same pathogenic activity as the fresh bacilli from the living animal; for by inoculation with the spores death was produced by splenic fever, with its usual abundance of the bacilli. He also noticed that in a specimen which most of the spores had fallen to the bottom, while few remained floating in the liquid, inoculation with the bottom fluid, thus richer in spores, produced death within twenty-four hours, while that with the surface fluid only in three or four days. The inoculation with the cultivated spores is no doubt the crucial test, for inoculation with blood containing bacilli does not prove that the contagium resides in the bacilli; it might reside in some other poisonous matter introduced at the same time; whereas the cultivated spores may be presumed to be free from other non-parasitic contagious poison. I am bound, however, to say that, on careful perusal of the details of the experiments, it appears to me the possibility of that was not excluded. To show that the cause of death in these inoculations was not

from ordinary septicemia from putrid matter, Koch inoculated several mice with minimal doses of putrid blood, putrid serum, and crystalline lens, all free from bacilli. Only two out of twelve died, and in these the blood was free from bacilli. And further to test the specificity of the *Bacillus anthracis*, animals were inoculated with a putrid crystalline lens in which had spontaneously grown a kind of spore-forming bacillus not distinguishable from the *B. anthracis*, but neither it nor its spores could produce splenic fever; nor did the spores of a bacillus cultivated in hay infusion by Professor Cohn. These facts, he thinks, complete the proof of the physiological specificity of the *B. anthracis* as the cause of the disease. Unless I must add, as above said, no other poison accompanied the bacilli or spores, although even in that case the persistence of the poison is hard to account for if it did not reside in the spores. For matter containing these spores could be dried into dust, again wetted, and dried repeatedly, kept in putrefying liquid for a week, and, according to Pasteur, exposed to boiling heat, without losing its infective power. This, however, is contradicted by Ewart, who found that the spores do not resist boiling heat, nor oxygen at twelve atmospheres. It is difficult to suppose that amorphous protoplasmic particles like graft-germs could stand such an ordeal. Until, therefore, new facts come to light, showing an equal power of survival by graft-germs, we must for the present place the splenic fever in the category of parasitic diseases. Some of the above facts are still disputed, but it would take too long to go into details.

Another disease which may be placed in the same category is the relapsing fever. This is a contagious epidemic which has been recognised as distinct from typhus and other fevers for above thirty years, and since 1872 it is known to be universally attended with the presence of a spirillum in the blood, named, from its discoverer, the

*Spirillum Obermeieri.** The evidence for the parasitic nature of this disease is similar, although far from being so complete, as that for the splenic fever, so I need not enter into it, but at once allow it to be placed, provisionally † at least, in the same category.

§ 8. We must here pause to point out that in admitting the last category a great leap has been made into the region of hypothesis. In the previous list the parasitic organism was an easily demonstrable morphologically distinct animal or vegetable, and therefore it was comparatively easy to connect it with the disease in the relation of cause and effect, whereas now the most we can do by simple observation is to determine the constant presence of a particular species, or even genus, in the disease, but which can and does exist in other circumstances without being accompanied with the disease. We are therefore compelled to resort to the hypothesis that, although the same in appearance and life history, the parasitic disease-causing-bacterium constitutes a variety physiologically distinct, in that it can secrete a noxious

* This bacterium is, however, not morphologically distinguishable from the *Spirochæte plicatilis*, which is often found in stagnant water, and even in the tartar of the teeth of healthy people. Spirilla are also found in the stomachs of healthy oxen (Cohn), and I may add, from my own observation, that the germs of a spirillum are found abundantly in the Liverpool water, and are swallowed in myriads every day, while relapsing fever is unknown here at present.

† Provisionally; for it is quite possible that when our knowledge of this disease is complete it may turn out that the parasite is merely a subordinate complication. It appears that spirilla were found in the recent famine fever of India; and it is probable they occurred in the famine fever of Ireland, in 1847. Either some internal cause altered the blood so that the common *spirochæta* of stagnant water and of the tartar of the teeth could live and multiply in it; or the cause of the famine coincidently acted on the *spirochæta* so as to produce the evolution of a specific variety, which entered the people and produced the fever. Is this last really probable? Some light may be thrown upon this by a fact observed by Mr. Dallinger and myself in our researches into the life-history of the bacteria, not yet concluded. Wishing to observe the *Spirillum volutans* separate from the

poison, or at any rate live and grow in the healthy body. This may be so, but it is obvious that we must have other proofs except the bare fact of disease accompanying their presence, for the cause may reside in some other poison while the bacteria are a merely subordinate complication. The strongest arguments for purely physiological specificity are derived from analogy, and were first given by Pasteur and F. Cohn, whose statements may be shortly summed up as follows:—The lactic and the acetous fermentations are chemically different processes, as also the ammoniacal urinary, and the mucous wine fermentation, and yet the organisms which produce these respectively cannot be distinguished by the microscope. The bacterial germs which produce the red, yellow, orange, and blue pigments, cannot be distinguished, yet on sowing them out the distinct colour appears. This obtains among the different genera of bacteria, and we may therefore admit purely physiological species as good species; or at least varieties or races which are persistent and breed true like morphological species. As, in fact, we see in plants,

numerous putrefactive organisms in the matrix-maceration, we tried it in Cohn's nutritive fluid and several other clear media, but in vain; it died speedily in them all, and we were for a time quite baffled. However, recollecting that it was a variety of spirillum which flourished in the blood in relapsing fever, we tried fresh (sheep's) blood serum, and found that it answered perfectly, and we could watch the lineal descendants of a few spirilla for many generations in the moist chamber, under the microscope. It is easy to imagine that a small diminution of healthy vital resistance (§ 12), induced by a non-parasitic cause of fever, might allow the spirilla germs in the drinking-water or the tartar to multiply in the blood, while it might not so act with regard to other saprophytes; for Billroth noticed that the commonest putrefactive organism, viz, *Bacterium termo*, does not thrive well in blood. But it is very difficult to imagine that the evolution of a particular specific variety of spirillum fit to breed in the blood should happen just at that particular time. Dr. Roberts (§ 8) compares the origin of specific bacteria to the "sporting" of plants; but sports occur only once in many thousand generations; famines cannot certainly be called common; that they should coincide must be a rare event, but that they should always occur together as a mere coincidence passes credibility.

especially cultivated ones; for of two trees, otherwise indistinguishable, one will bear sweet and the other bitter almonds —the latter being poisonous. In fact, if the parasitic theory of disease be true, this would by analogy furnish an explanation of the origin of infectious diseases; for the sweet and bitter almond, and many kinds of variety in fruits and vegetables, are produced by variation in and descent from common stocks. As an example of such variation, or "sporting," Dr. Wm. Roberts cites from Darwin the origin of nectarines:—"A peach tree, after producing thousands and thousands of peach-buds, will, as a rare event and at rare intervals, produce a bud and branch which ever after bear only nectarines; and conversely, a nectarine, at long intervals and as a rare event, will produce a branch which bears only peaches ever after." Again, in the different sorts of yeast, the formation of races by artificial selection is demonstrated by Rees. Also, just as summer rye is worthless for winter seed, although both races are descended from a common stock, so the upper yeast is useless for Bavarian beer, and almost every kind of wine or beer has its own barm. On these and similar grounds from analogy, F. Cohn constitutes a special group of physiologically specific bacteria, called the pathogenic bacteria. All of these, except two, belong to the globe, or sphero-bacteria, and already distinct names are given to those supposed to belong to the different infectious diseases, such as the micro-sphæra vaccinæ, the micrococcus diphthericus, the micrococcus septicus, &c. The same principle is extended to erysipelas, smallpox, scarlatina, cattle plague, glanders, measles, and even tuberculosis, all of which are supposed to have their physiologically specific micrococcus or sphæro-bacterium not distinguishable from ordinary saprophytes; the only exceptions being the two above diseases, splenic and relapsing fever, which depend on rod-bacteria. Oddly enough these two happen

to be the only ones in which anything like proof of the causal connection with the diseases can be admitted to exist. All the rest, without going into detailed discussion which would be too extensive, I may say at once are as yet entirely destitute of proof and altogether hypothetical. In none of them, except the two already named, has the uniform presence of any single species been demonstrated, far less has the disease been traced to the various organisms which have at different times been found in them. To unravel the complications of the relation of the bacteria and micrococci found in various infective diseases to the disease itself, let us keep in view the different categories in which such organisms can be placed in relation to the disease.

§ 9. These categories are three:—1st, true parasites which live and thrive on healthy animals and plants, and possess special organs to enable them to prey on the juices of the host (suckers: *haustoria*), and which cannot continue to live without the host; 2nd, fungi which thrive on dead organic substances, and can therefore be cultivated on artificial nutriment out of the host; but they are able also to thrive on healthy living animals and plants, and thus excite disease, and in plants consume and destroy them; 3rd, fungi which usually are saprophytes, living on dead organic matter, and unable to attack healthy uninjured tissues, but they can grow and multiply in parts or organisms whose vital powers are lowered by injury or disease (§ 11); in plants, for example, the ordinary moulds will take root and grow on any injured part, especially on fruit, and become injurious parasites. It is evident that the existence of the last category strikes a blow at the doctrine of specific organisms as the sufficient cause of corresponding infectious diseases. The presence of bacteria or other fungi in disease may thus depend on two causes, either, 1st, an alteration in the specific

vital properties of the bacteria enabling them to live and thrive in the healthy body as parasites, and thus produce diseases corresponding to the specific character of the parasites; or, 2nd, an alteration in the tissues and fluids of the body itself, which enables ordinary bacteria, or micrococci, to live and grow therein. In this last case, their presence is merely secondary and a complication, although it may add greatly to the gravity of the original disease.

§ 10. It may well, therefore, be that the discovery of micrococci, even constantly in particular infectious diseases, by no means proves the causation of that disease by specific parasitic germs. Each disease must be studied by itself, and if there is another cause of infection, such as graft-germs, to be treated of presently (§ 17), we have simply to determine whether it is to be arranged under the parasitic or the graft division; and I venture to predict that many diseases that are somewhat hastily assumed to belong to the parasitic division, from the presence of micrococci, will be met by the third category of the foregoing paragraph and transferred to the graft division. Even some diseases we have admitted into the parasitic division, in the second category of § 9, have their specificity determined as much by the specific vitality of the parts on which they take root as by the character of the fungus itself. For example, in the different forms of ringworm, *Favus*, *Herpes tonsurans*, and *Pityriasis versicolor*, a specific fungus was originally given to each, called respectively *Achorion*, *Trichophyton tonsurans*, and *Microsporon furfur*. More recently, however, the question has arisen whether they do not all depend on one fungus, and this has been answered in the affirmative by the celebrated dermatologist, Hebra, who considers that to be the *Penicillium glaucum*. But since then Grawitz, by more careful separation, and culture, and experiment, determines it to be the *Oidium lactis*. Why this should produce differ-

ent diseases depends on the specific difference of the subjects on which they fall, as to age and other predisposing causes. The fungus has an irritating quality, which produces herpetic inflammation, and thus fluid exudations, which favour its further growth. This is confirmed by the facts that parasiticides applied locally can cure the disease, but they are greatly aided by internal medicines, which control the concomitant inflammation. The transference of the fungus after cultivation, it is alleged, gives the disease, therefore we must admit it among the parasitic diseases. Not so those in which the bacteria or micrococci belong to the third category above. (§ 9.) As examples, we may notice aphthæ, diphtheria, smallpox, and erysipelas. In all these micrococci and mould-fungi are invariably found, and their presence adds greatly to the severity of the disease, or gives it actual fatality. Here, also, may be arranged all those diseases in which micrococci or bacteria are not regularly found at some stage of the disease, but in which they may occur at the closing, or so-called putrid stage of disease, and profoundly affect the blood. Even in the rapid death which is produced by over-driving of perfectly healthy cattle, living bacteria are found in the blood. In the aphthæ or thrush the same method of cultivation and experiment has been applied by Dr. Grawitz, and he found that among numerous bacterial and mould-fungi, more or less present, the only invariable form is a species of torula, which can produce the alcoholic fermentation, and appears identical with the *Mycoderma vini*, or common mould pellicle, which infests fruits and vegetable juices. He now attempted to produce the disease with this, but all attempts with healthy animals failed, even if given in milk to young cats and dogs for weeks. But if given to quite young animals, from three to eight days' old, which had not been fed with mother's milk, and whose health was obviously deteriorated, then it

produced disease and death, with aphthæ on the tongue, fauces, and even the larynx. The same principle applies to diphtheria, erysipelas, smallpox, and other infectious diseases, in which the micrococci are incapable of alone producing the specific disease, or indeed disease at all in moderate dose, but after the true specific cause has begun to operate they supervene and aggravate the evil. In simple erysipelas, for example, a zone of micrococci borders the spreading inflammation of the skin. These seem not to be virulent, and to act only mechanically. Their presence most probably depends on the fibrinous effusion which marks that stage of the disease, forming a good nidus for the growth of the micrococci, for in the subsequent stage of the disease they are destroyed and absorbed. In certain cases of small-pox and diphtheria the lining membrane of the heart is invaded by vegetations of the same sort, which produce death by choking up the capillary vessels, not only in the heart, but also of the liver, kidneys, and lungs.

§ 11. *Ubiquity of fungus germs.*—Whence, then, are these organisms derived if they do not pass into the infected body as the causal agent of the disease? The answer is simple. The germs of them are ubiquitous. This applies to all the three natural groups of the lower fungi, viz., (Naegeli) the mould-fungi, the sprouting or yeast-fungi, and the fissiparous fungi or bacteria. The evidence of this may be shortly summed up as follows:—All the air we breathe and live in contains organic matter, which includes spores of more or fewer of the above fungi. In pure country air the quantity of organic matter amounts to one grain in 200,000 cubic inches, and in the less pure air of towns to one grain in 8,000 to 10,000 cubic inches. (Angus Smith.) The whole of this quantity of organic matter does not consist of spores or germs, but such is the incredible minuteness of these (each of which has been calculated by Naegeli to weigh

the thirty thousand millionth of a milligram) that exposure to the air is sufficient to produce the so-called spontaneous fermentation and putrefaction of organic matters, and the growth in them of some of the known fungi, in a longer or shorter time, according to the degree of contamination of the air. Again, the first portions of water collected in a shower of rain contain more fungus-germs than subsequent portions, and the air becomes purer from them after rain. All water, from whatever source, which has once touched the ground, contains abundance of the above germs. Consequently all animals and vegetables on the face of the earth are continually receiving abundance of fungus-germs in the water essential to their existence. Thus, in the air we breathe, in all that we eat and drink, and touch, and lie on, we are continually exposed to the reception of germs. Accordingly, bacteria, and various fungi and germs, have been detected on all parts of the surface, and of the mucous passages open to the air and in the organs communicating with the mucous membrane. They are found in myriads on the tongue and in the tartar of the teeth, in the nose and throat, and all through the alimentary canal, into which countless myriads are continually poured with our food and drink. Even developed bacteria have been found in the liver and spleen, and in the blood of healthy animals in certain cases; but the germs or spores are diffused through the interstices of the tissues, where, under favourable circumstances, they may come to maturity, as bacteria are sometimes found in abscesses shut off from the air. They are found also in the perspiration of the axilla, the face, and other parts; also in the fluid of blisters raised artificially. Nay even, they are found in seeds and ova; the pink mould has been found in the middle of a nut, and the *Dactylium soyerium* in an unbroken egg. The cells of plants produce fungi, which fructify within them. In short, we may take it as established that the whole of the

higher organisms are interpenetrated perpetually with the germs of the lower fungi, and these may even develop in small numbers without much disturbance of health.

§ 12. *Vital Resistance.*—On the other hand, in the healthy body an equally constant process of elimination and destruction of these germs is perpetually going on. In the air passages the ciliated epithelium is always engaged in expelling spores, as well as other foreign matters, with the surplus mucus. And the mucous corpuscles here and in the other mucous membranes decompose and destroy them. Also the blood, and the healthy juices and secretions, are unfavourable media for their development, while the bioplasts in the blood and of the tissues destroy and consume them; so that spores are ordinarily not to be detected in the blood and healthy tissues. But only let the vital changes of the living matter slacken ever so little, then the germs escape destruction and accumulate in the interstices of the tissues, and are ready, on further progress of disease, to enter upon growth and development. Of all this, abundance of proof is now extant as the result of experiments which cannot be here adduced in detail. It has been found that injections of putrid fluids full of bacteria can be made into the blood of healthy animals in moderate quantity, with the result of producing only slight febrile disturbance, which is soon recovered from. Here the noxious chemical putrefactive products are in too small quantity to kill or greatly depress the vital powers, and the bacteria and germs are destroyed and consumed or eliminated. The law of quantity here holds good (§ 2); but let a certain moderate quantity of this putrid injection be exceeded, then the animal succumbs to septic poisoning and growth of bacteria. In other experiments, certain spores of the mould-fungi were found to be partly eliminated by the kidneys, and partly dissolved and destroyed in the blood, apparently by the

agency of the living white corpuscles. On the other hand, the effect of disease in lowering vital resistance is demonstrated by the experiment of Chauveau, who injected into the blood of rams, before the operation of bistournage, a quantity of putrid fluid, containing bacteria, too small to kill the animal; then, when the bacteria and germs were well distributed through the blood, the subcutaneous rupture of tissue, in which the operation consists, was performed. The part being then cut off from its supply of blood, has its power of vital resistance so far lowered that growth of bacteria, putrefaction, and septicemic infection takes place. In the healthy animal the operation is harmless, and the part cut off from the circulation gradually passes into fatty degeneration and atrophy; likewise, the injection of the same amount of putrid matter, without the operation, is harmless, but both together are fatal. By the expression vital resistance is meant merely the necessary incidental result of healthy living action, not any specific property or power, such as the imaginary *vis medicatrix naturæ.*

§ 13. We thus see that although fungi may be capable of producing disease primarily, yet the mere fact of their presence in any given disease is no proof that they are directly the cause of it, as there are other ways of accounting for their presence. Doubtless all germs are not present everywhere at the same time, so it may be difficult to account for the invariable presence of one particular form of bacteria in one disease by merely chance spores. But it is already a weak point in the proof of parasitic-germ theory that you can never inoculate with the specific bacterium, say *bacillus* or *spirillum,* without at the same time introducing some of the diseased secretion, or graft-germs, which might be the true contagium; so also, if the latter is the true cause, you can never escape inoculating the particular bacterium along with it which is best adapted to thrive in the disease

secondarily. We have seen that the hypothesis of physiologically specific bacteria was put forth to account for the pathogenic power of bacteria not visibly different from the chance bacteria. Naegeli * also, while objecting to the idea of truly different species, either for disease or the fermentations, owing to the enormous time required for variation of species, adopts the theory of variation in the secretion, which, he thinks, may be brought about in a much shorter time; and thus may be accounted for the changes of epidemic diseases, and the rapid gain of virulence of septicemic disease. But it seems to me that we have no ground to assume that the varieties of yeast and pathogenic bacteria can be evolved with anything like the required rapidity. And, besides, it is not a mere variation in their secretions which must characteri se the pathogenic bacteria, but it is the adaptation of the bacterium as a parasite, *i.e.*, its constitution must be so changed that it can live and breed and grew from the most minimal dose in the healthy body, which faculty the ordinary bacteria do not possess. Now, it is generally held that parasites are degradations by variation and natural selection from independent species, but that this process, like all change of species, is only effected in the course of years or centuries. This is quite contrary to what takes place in diseases, where, in a few days, or even hours, ordinary chance bacteria are found living and breeding in the living body, on account of a change in the body and not in the bacterium.

After all, Naegeli, an adherent of the parasitic-germ theory and the physiological variation of the pathogenic bacteria, finds the theory insufficient to explain the specific nature of the infectious diseases, and is obliged to suppose, in addition, that the bacteria absorb and become charged with a morbid secretion from the diseased host; in fact, that they are also carriers

* *Die niedern Pilze*, von C. v. Naegeli, München, 1877.

of an infective or diseased stuff; or, at least, that to produce the full disease some such stuff should be transferred at the same time, whether on or in the bacteria. An analogy for the process is, he thinks, as others have done before him, given by the growth of galls on plants, viz., along with the ovum is deposited by the insect some acrid matter, which excites inflammatory and exuberant growth possessed of less vital resistance than the healthy tissue, and on which, therefore, the ovum can be nourished. Now, no doubt this corresponds to a certain extent with what happens in some of the truly parasitic diseases, *e.g.*, the ringworm; but it opens the door to another cause of the specificity of infectious diseases, viz., morbid secretions, and even graft-germs, which may be the efficient cause, while the bacteria are merely a secondary complication. Indeed, it is particularly noticed by Darwin, that the great variety and fixed character of the different species of galls indicate the morbid specific power of the poison of the insect which produces them respectively. The admission of such a specific poison in the infectious diseases, besides the parasitic germ, vitiates the decisive character of all mere inoculation experiments, and throws us back upon the clinical history of these diseases to determine how far the different theories harmonise with the well-known facts.

§ 14. The following are a few of the cardinal facts of smallpox, which may be taken as the type of the specific contagious fevers:—

1st. A latent or incubative stage, exactly limited to twelve days.

2nd. Almost perfect health during, and abrupt termination of, the latent stage, and invasion of the initiatory fever.

3rd. Immunity from a second attack.

4th. The inoculated disease is very much milder than the natural, but protects as completely.

5th. The latent stage much shorter in the inoculated disease, lasting only seven days.

6th. Vaccination still milder and its latent stage shorter, while it protects as well.

7th. Several vaccine pocks protect more completely than one.

§ 15. The first point is the absence of illness during and the abrupt termination of the latent stage. It is difficult to see how this can be reconciled with the parasitic theory, for the only mode, as yet known, of propagation of the bacteria, on which the disease is supposed to depend, is the fissiparous, or that by division into two. This produces a progression on the whole gradual, although more rapid at the later than the earlier stages; and from the time the number is sufficient to produce any perceptible effect at all the symptoms should increase gradually. It is therefore impossible to understand how in smallpox there should be no symptoms at all for twelve days, and then that the disease should suddenly burst forth in its full violence. Again, no matter how much or how little of the contagium be introduced in the inoculated disease, the length of the latent stage is the same; this also is against the theory of the multiplication of parasites, for the greater number should multiply faster and shorten the latent stage, as was indeed found by Koch in respect to splenic fever. (§ 7, p. 16.) It has been attempted to explain the latent stage by supposing that the parasite was in a different cycle of its life history when introduced, and the instance is given by Henle of the muscardine—a true parasitic disease of silkworms—in which it makes a difference whether the ripe or unripe filaments were used for inoculation; in the latter case the disease broke out much sooner, for the unripe filaments continue to grow at once, while the spores require time for their development. But this only serves to make the contrast between

the specific contagious diseases and the parasitic disease the more glaring, for the disease which had a shorter latent stage was not milder, but, on the contrary, more rapidly fatal than the natural cases, whereas the characteristic fact about the smallpox is that the inoculated disease not only has a five days' shorter latent stage, but it is out of all proportion milder, so as to be counted among the trivial diseases. Again, notwithstanding the mildness of the inoculated disease, it protects as completely. This immunity from a second attack, after the natural as well as the inoculated disease, is itself wholly inexplicable by the parasitic theory. As is also the fact that another similar poison, viz., the vaccine, can protect as well as the smallpox poison itself, as are also a number of the details of the process, especially the fact that several vaccine pocks protect more completely than one; for with a parasite capable of reproduction to infinity, what could it matter a few dozen more or fewer parasites? The immunity from a second attack is, in fact, acknowledged to be inexplicable on the parasitic theory by the best pathologists among those who are inclined to favour it; and the attempts to explain it by less able men only make the difficulty more palpable. As, for instance, when it is supposed that the body of the host contains in health some pabulum suitable for the parasite, and where this is exhausted, not only the parasite stops breeding, but the patient is never again able to nourish the same parasite. This would be a remarkable kind of pabulum, for the loss of it does no harm to the patient, nor does the loss of a dozen other kinds of pabulum which he keeps on hand for the other specific diseases. As far as we know of bacteria, they are also not so very particular, and parasites mostly go on devouring the substance of the host till death. So, why the specific diseases, if they are parasitic, should ever stop, as they do, and that in a curiously definite and fixed way, is

another difficulty, and it would be a wonder that any man or beast should survive were infectious diseases dependent solely on parasitic fungi with such tremendous powers of diffusion, reproduction and destruction, capable of fastening on and multiplying in the healthy body. It is unnecessary to pursue this part of the subject further, so we may conclude that it is impossible to reconcile the clinical facts with any theory, such as the parasitic, which places the cause of them solely in the changes occurring in something foreign to and independent of the diseased body; but that they involve the essential co-operation of the organism itself as the chief, or, at least, an integral part of the process. So we must now turn to the alternative theory, viz., that of tracing the exciting cause to morbid secretions thrown off by the diseased body, coupled with the additional theory that these may contain or consist of particles of living matter.

§ 16. *Morbid Secretions.*—By secretions are meant exclusively those compounds which are formed by purely vital processes. In the vast variety of the products of vegetable life we have abundance of examples of the power of vegetable secretions to act as stimuli on living beings, from the mildest condiments, perfumes, and medicines, up to the most rapid and virulent poisons. In the animal kingdom we have secretions, such as mucus, saliva, pepsin, bile, milk, &c., which fulfil most important functions for the health of the animal itself, while others are weapons of offence or defence, by their power as poisons, in all degrees, from that of the gnat to the rattlesnake. All secretions are liable to be perverted or diseased by a great variety of causes, some even mental, and which act with extreme rapidity, and, in consequence, irritate and excite disease in the individual itself. And as most diseases are attended with the discharge or throwing off of vitiated secretions, it is natural to anticipate that these should produce disease in others. Accordingly,

pathologists have generally admitted diseased secretions as the probable cause of contagious and miasmatic diseases. In Fletcher's *Pathology* it is laid down more particularly that the exciting cause of all contagious diseases consists of diseased secretions thrown off by animals affected with the same disease; while miasms, or malarious poisons, consist in diseased secretions thrown off by vegetables in a state of disease. This last distinction has not yet received the attention it deserves. To illustrate further the theory of diseased secretions, a person with a contagious disease may be looked upon as throwing off a secretion which, in virtue of its vitiation, is noxious to others, just as a venomous serpent secretes a poison in health; and the analogy is closer when we notice that many contagia are thrown off by secreting organs; *e.g.*, the virus of rabies by the salivary glands, scarlet fever by the glands of the throat and skin, measles by the mucous glands of the nose and air passages, typhoid by those of the intestines, &c. But the word secretion must not be limited to glandular products, for it may apply also to all products of perverted nutrition, such as pus, and sanies, and exudations from diseased tissues, or from the blood itself. Thus, if we include the last, viz., all kinds of detachable products of morbid nutrition among secretions, we can perceive that "diseased secretions" form a wide enough category to include the exciting causes of infectious and contagious diseases. And if we state, simply as an ultimate fact, that some have the power of causing a secretion of matter like themselves [contagia] which others have not [venoms], we probably say all that is certainly known, while renouncing the attempt to explain the remarkable difference between the two. Nevertheless, pathologists cannot rest satisfied without hypothetical attempts at explanation, among which, those tracing it to chemical changes in the secretions, independent of the purely vital

action concerned in their formation, are unworthy of attention, and for the most part unintelligible; while of those tracing it to the presence of living matter, the parasitic category has been already judged.

§ 17. There remains now the hypothesis of Dr. Lionel Beale, the discoverer of the Protoplasmic theory of life, who lays it down that the miasms and contagia are not only formed from the protoplasm, or living matter, of the sick person, like all other secretions, but they consist of actual portions of protoplasm, or living matter, which, being transferred to a new body, continue to live and grow therein, thus causing the phenomena of contagion and infection. They are thus living portions of the diseased body engrafted on a healthy body, and the name of graft-germs may therefore with propriety be applied to them. The word is the more appropriate since it was the one originally given to the operation of inoculation, as is reported in the celebrated *Letters* of Lady Mary Wortley Montague, whose words are:—"The smallpox, so fatal and so general amongst us, is here [Turkey] entirely harmless, by the invention of *grafting*, which is the term they give it." The revival of this word, to designate transplantable disease-particles, is due to Dr. James Ross, in his very clever book, *The Graft Theory of Disease*. He proposes to call the contagium particles simply "grafts," but I think it will be more convenient to use the expression graft-germs. Dr. Beale, who is the discoverer of the theory, calls them simply "disease-germs;" the word germ being here quite proper and intelligible, for, as he says, "any living particle growing or capable of growth may be termed a germ." To trace this theory to its root, we must remember that all diseased processes ought to be traceable to modifications of healthy ones, or, at least, to a strong analogy with them. Now, on the protoplasmic theory, all secretions, as well indeed as all formations of tissue, are the result of the

transformation, and, in fact, for the most part, the death of protoplasm—the one only living matter. The great majority of the secretions which in health subserve the purposes of the life of the body as a whole, are not living, nor do they contain any particles of living matter; *e.g.*, the gastric and pancreatic juices, the bile, the perspiration, the tears, milk, &c. But there are some others which naturally contain particles of living matter or bioplasm, capable of living for a certain space of time after separation from their point of origin. Of these the most notable are the spermatic and the mucous secretions. We are therefore justified in including the detachment of living matter among the functions of secretion, which last term may thus cover every variety of pus or similar matter thrown off by a truly vital process, although morbid, whether by the glands, the tissues, or the protoplasm contained in the blood itself. In health, the soft viscid transparent fluid we call mucus, is a dead product of the transformation of the protoplasm of the mucous membrane. The fixed protoplasm is not only being continually consumed in the formation of the soft fluid, but portions of it are thrown off living, and survive for a time embedded in the mucilaginous fluid. These are the mucous corpuscles, and they can be seen, with a power magnifying 700 diameters, exhibiting movements like an amœba. During this time they continue to perform their function, being transformed into the mucous fluid, and gradually wasting away. Now, under certain conditions, including over-stimulation and the excessive supply of nutriment, the growth and sub-division of the bioplasts becomes more rapid, while the elaboration of the proper fluid is less perfect; and, "in some cases of inflammation of the mucous membrane, all the viscid matter secreted upon the surface appears to consist of bioplasts, ordinarily termed *pus corpuscles;* while, on the other hand, the proportion of formed material, which was abundant in

ordinary mucus, is exceedingly small. The bioplasm has multiplied so fast that there has not been time for the production even of the soft mucus." * This is the key to the whole theory. All living beings are made up of a vast number of living units or plastids, in groups, each of which has its specific developmental power, inherited from the embryo, and continually being transmitted to their descendents while the conditions of health endure, as long as age permits. Any disturbing cause, such as excessive stimulation, or stimulation of a morbid quality, or altered supply of nutriment, may hurry on vital action and check developmental power from reaching its healthy standard, and the subsequent bioplasm is thus germinally degraded. Germinal degradation is, however, compatible with, and often attended with, increased powers of growth, and altogether an assimilation to lower orders of living creatures, whereby a greater viability in a separate form and other qualitative distinctions are acquired.

Now, although the protoplasm of all tissues and parts is specifically distinct, and, owing to that distinction, in one case produces nerve, in another muscle, in a third bone, in a fourth epithelium, and so on, yet they all, under certain conditions in which their growth is hurried on too fast, give rise to "a common form of germinal matter or bioplasm differing in properties and powers from them all. This is the form of bioplasm known as *pus*, which may go on multiplying for any length of time, producing successive generations of pus-bioplasts, which exhibit remarkable vital properties, although they cannot form tissue, nor produce tissue-forming bioplasts of any kind whatever." (p. 114.) Pus is thus the product of irritation of the protoplasm of all tissue, and not derived from the white corpuscles of the blood alone, as has been more recently upheld by Cohnheim.

* *Disease Germs*, by Dr. Lionel Beale, F.R.S, 2nd Edition, p. 101.

The exudation of white corpuscles from the inflamed capillaries in inflammation was discovered by Beale in 1863, together with their transformation into pus-corpuscles, but it was then shown by him that this was only one of the sources of pus. The transformation of the to be detached mucus-corpuscles into a degraded but more viable and rapidly growing form of protoplasm, viz., pus, is the first step; and the degradation of the protoplasm of the fixed tissues and of the blood into the same, is the second step in our comprehension of the *contagia* or germinally degraded bioplasts. It has been long known that pus was liable to be of an acrid and irritating nature, and it appears now that this depends on its containing actually living bioplasts, and on the character and degree of germinal degradation of their vital powers. For the pus-corpuscles, as usually figured in books, are dead, as are also the majority of those contained in abscesses in the living body. But many can be found living, especially those formed by the degradation of the protoplasm of mucus and epithelium cells, and these form the first links in the chain of degrees of viability, and differentiation of the disease-germs. The living pus-corpuscle has no cell-wall, but is a formless mass, in continual movement, pushing out protrusions, which become detached, and form new corpuscles. In inflammation of the mucous membrane of the bladder, Dr. Beale has seen them living and moving forty-eight hours after separation from the body, and I can confirm the fact from my own observation. Dr. Beale also states that these same corpuscles can be kept alive in water to which a little serum or albumen has been added. From what we thus know of the viability of pus, which is comparatively so little removed from health, we can easily imagine how the further degraded and differentiated bioplasts of the specific fevers may have sufficient viability to allow tho preservation in moist or liquid media, and even the partial

desiccation and transportation through air characteristic of miasms and viruses. It may be said that these last differ so much from pus in appearance, that we cannot reason from any analogy between them. But it is not so; the difference between the appearance of common pus and the clear vaccine virus, for example, is no doubt great, but that depends on the accidental ingredients in which the active part common to both is suspended. (§ 2.) "It is impossible to distinguish many pus-corpuscles from lymph-corpuscles, white blood corpuscles, and many other masses of germinal matter; indeed, if we examine the developing brain of an embryo at an early period, it will be found that this important structure consists of nothing more than a number of spherical cells, which could not, by any means we are yet acquainted with, be distinguished from many forms of pus-corpuscles."* In fact, the bioplasts constituting disease-germs simply share in the common characteristics of all protoplasm, viz., that all kinds are, to outward appearance, exactly alike, from that of the simplest vegetable up to that of the brain of man, although in vital properties they differ so enormously. This is no hypothesis, but a simple fact, and is therefore in favour of the graft-germ theory against the parasitic theory, for the impossibility of finding morphologically specific organisms in the specific fevers, drives its advocates to the hypothesis of physiological specificity of common micrococci. In the graft theory no specific outward distinction is expected or required for the abundant bioplast formations which are met with in the specific fevers, and many of which have been erroneously described as micrococci.

§ 18. Together with the mucous and epithelial cells of the mucous membrane and glands, the bioplasm of the blood itself forms the chief source of the degraded bioplasts which constitute disease-germs. Not only does the blood contain

* Beale, *Disease Germs*, p. 180.

the visible white corpuscles, but an infinity of smaller particles of living matter, and these, as well as the more palpable white corpuscles, become degraded, and thus the source of the disease-germs of contagious and specific fevers.

In all fevers, even when arising from simple non-specific causes, such as catarrhal and inflammatory fevers, this bioplasm of the blood is increased in quantity, and to a certain extent, no doubt, altered in quality, so we can easily imagine it to degenerate, as mucus-bioplasm does, into pus, and thus become the contagious matter of the specific fevers, or, at least, of those in which the blood is specially involved. Now, we are reminded by Dr. Beale that the living matter of the epithelial cells and of the blood possesses remarkable formative powers, which survive even in the adult, and, in particular, the blood bioplasts, when exuded, may develop into analogues of some of the lower tissue-cells, and thus take part in regeneration of tissue and healing of wounds. This is attributed to their being descended from the protoplasm of the germinal area at a period of development before that of most of the fixed tissues, and they therefore inherit some of that more general formative power which enables some animals lower in the scale to regenerate lost complete parts. It is to be noted also that it is just this class of living matter which furnishes the basis for all infective diseases.

It is therefore hardly necessary to go beyond blood and epithelial bioplasts in considering degeneration or degradation of living matter as the cause of infective matter. And with protoplasm of such formative powers, we can easily imagine that degradation may take place from mere alteration in the external essentials of life, viz., pabulum, conditions, and stimuli; also when protoplasm, so degraded, has become more viable, it may be mutually transplanted, not only between one individual and another of the same species, but also between others widely different in the

biological scale, even to those of the vegetable kingdom. On this point, as on many others, Dr. Beale has been anticipated by Fletcher, in whose *General Pathology* (1842) we read:—"Vegetables secrete like animals, and are liable by disease to have their secretions vitiated. Now, diseased animal secretions produce contagious diseases; analogy would therefore lead us to suppose that those miasms from which infectious diseases arise, such as those of marshes, are in like manner secretions from diseased vegetables." This position was supported by the facts known at the time, and now Dr. Beale adds from the facts now known, including his own discoveries, "it is not improbable that the germinal matter of some of the lower, simpler plants and animals, when exposed to altered conditions, may give rise to morbid forms, bearing a relation to their normal healthy, living, germinal matter, similar to that which pus bears to the germinal matter of healthy tissues. It may be that the matter of the malarial poison may thus result, in which case it must be regarded as a morbid bioplasm of some low organism—not as a *species* of any kind whatever—but as a deteriorated form of living matter, freely multiplying, but incapable of returning to its primitive healthy state. (p. 117.)

It is unnecessary to adduce, in support of this, the now admitted fundamental identity of life in plants and animals, and, in particular, the facts more recently made known by Charles and Francis Darwin, but I may quote a striking illustration, given by Dr. Beale himself, of the analogy of the living juices in the two kingdoms:—"If the clear transparent material which moves round the cells of the *Vallisneria* and other plants be carefully examined under very high powers, magnifying upwards of 2,000 diameters, it will be discovered that this is not a simple fluid, like water, containing the nucleus and chlorophyl. But the apparent fluid has suspended in it an infinite number of particles of

living matter, like those of which the amœba, white blood-corpuscles, and other forms of living matter consist." He then goes on to state that it is to the vital movements of these particles that the circulation in the cell is due, and that these particles in the vegetable cell bear the same relation to the nucleus as the similar fine protoplasmic particles do to the white corpuscles of the animal blood, while the red corpuscles correspond to the chlorophyl particles.* Having thus, as a basis, the existence of certain kinds of protoplasm of a lower order of individuality forming an essential part of higher organisms in which degradation and the capacity for a certain amount of independent viability and growth, we next enquire for experimental proofs that such really happens. It is impossible here to go into details, but it may be simply said that abundant proof has been furnished by the experiments of B. Sanderson, Lewis and Cunningham, Onimus, Vulpian, Clementi and Thin, and others, of the following points :—

If you introduce into the peritoneum any common irritant, such as solution of ammonia, boiled so as to sterilise it from bacterial germs, an inflammation of moderate intensity is set up. If now a very small portion of the exudation fluid of this first generation, as it were, be injected into a second animal, we have a much more intense inflammation set up. From this second generation a third and fourth, and further, may be derived, each increasing in virulence and intensity, till death is produced in a few hours by the introduction of a fraction of a drop. If, however, the matter of the first inflammation be boiled, it has no such poisonous effects ; the poison also is non-dialysable—in these two points agreeing with the theory of degraded living matter. It is true that, although no bacteria are introduced at first, they are found in the subsequent increasingly poisonous

* Beale, *Disease Germs*, p. 189.

inflammation-fluids, derived, no doubt, from the ubiquitous germs (§ 11), and brought to maturity by the diminished vital resistance (§ 12) of the diseased state. But they are not the cause of the virulence of the disease, for a similar amount injected without the inflammation-poison would be innocuous.

It has likewise been found that the matter of inflammation of the cornea, produced by a non-specific cause, *e.g.*, mechanical injury, becomes contagious. (Eberth.) Perhaps the most striking development of an organic poison by successive inoculation is that discovered by Davaine, and confirmed by many experimentors. Here the case is generally complicated by the introduction of bacteria at first, and it would require too much space to go into the whole question, so I merely note the undisputed facts which bear on our present subject. These are the rapid increase of virulence with each generation of inoculation and the dosage. At first a considerable quantity of putrid blood* requires to be injected into the circulation in order to produce death by simple putrid poisoning. But by successive inoculations from the blood of this first animal, the virulence of the poison increases so much and so rapidly, that, in a few generations, the tenth, the hundredth, thousandth, millionth, and finally, it is said, even the trillionth † of a drop is sufficient to produce death. No chemical poison, or even venom, approaches in the remotest degree in deadliness equal to this. Nor does the effect of self-reproducing ordinary septic bacteria bear any comparison with it, for a palpable quantity is required to produce any evil effect.

* Even putrid albuminous matter, boiled in alcohol, thus destroying all bacteria, will produce the first generation of septic blood-poisoning (B. Sanderson); also dialysed putrid products. The poison is here evidently chemical, but Onimus found that the virus of true septicemic blood, *i.e.*, subsequent generations, is non-dialysable.

† This has been doubted, and attributed to some experimental error. Clementi and Thin, however, confirm the principle up to beyond the hundred millionth.

We may therefore consider it established that by the operation of non-specific causes a contagious phlogogenic (or inflammation-producing) virus can be developed *de novo* in living beings.

§ 19. We have thus a solid basis of fact and experiment on which to rest an explanation of the origin of virulent and contagious diseases by perversion of the living processes within the body itself. In this way may be easily conceived to arise infective blennorrhœa, ophthalmia, erysipelas, pyemia, and puerperal fever. The conditions of the origin of this last, indeed, form in crowded communities and in lying-in hospitals an involuntary experiment on a large scale, in inoculating successive generations of increasingly degraded blood, mucus and pus-bioplasts, till they acquire the fatal virulence of that dreaded disease. In the above class of diseases the graft-germ theory fits far better than the parasitic-germ, for the existence of purulent and other degraded living particles cast off from the diseased body is undoubted, and the analogy of transfusion of blood and transplantation and grafting of skin, periosteum, and other tissues, shows there can be no difficulty in their being also transplanted and growing in other individuals, thus constituting contagion. While the *rapidity* of the process of alteration and degradation is quite what we should expect as disease, whereas it is quite contrary to what we know of the production of new species, or even varieties of independent organisms, such as parasites. With respect to the origin of the specific fevers, which never arise spontaneously now, the two theories are equally at fault as regards positive knowledge. But, as in all febrile states, arising from common causes, the white corpuscles of the blood and the bioplasts of the capillaries are always in a state of over-action and rapid development, they are thus in a state bordering on the degree of degradation which would make them contagious particles, and it is not difficult to suppose that in certain

circumstances of famine, over-crowding, and other noxious influences, they may have become fully developed and differentiated into the specifically distinct graft-germs now known.*

* Although neither chemical agencies, organic or inorganic, nor septic organisms, constitute the external factor in the proximate cause of the specific diseases when formed, yet all these may play an important part indirectly in the causation of the degradation of the living plastids, which become the starting-point of a contagious disease, not necessarily like the direct effects of the noxious chemical agent, but always henceforth retaining its own specific character. Hence popular opinion is to a certain extent justified which attributes the origin of epidemics to noxious influences arising from the great convulsions of nature, such as earthquakes, volcanic eruptions, floods and droughts, and from the permanent evils of dirt and bad drainage. For example, hay-fever, as proved by Dr. Blackley, of Manchester, is caused by the irritation of the pollen of the grasses acting on certain predisposed individuals, and is, of course, not contagious. But it would not be difficult to imagine that were a number of such patients kept in close proximity, the mucus-corpuscles thrown off in the cough, and inoculated and re-inoculated through the air from patient to patient, might become degraded into pus, and finally into infective catarrh-germs. It is possible the influenza epidemics may have so arisen: first, a catarrh caused by chemical, probably plant, emanations, and then continued by an animal poison formed in the system. Probably epidemics of yellow fever arise in a similar manner, for, although apparently depending on malaria, yet it never arises except in pretty closely-settled communities of men, whereas the intermittent fevers are the direct effect of the malarious germs on solitary individuals exposed to them. Yellow fever, therefore, depends probably on an animal poison developed in the system, owing to the noxious action of chemical agencies, probably drawn from plants. This applies equally to the so-called diblastic theory of this and typhoid, cholera and the miasmatic-contagious diseases, which assumes the existence of two poisons, *i.e.*, a ground-poison and a body-poison which, by their co-operation, produce the disease. The addition of the graft-germ theory gives us, in fact, increased scope for explanation of the labyrinth of apparently contradictory facts to which the parasitic theory alone fails to give us the clue. The rôle of bacteria in the causation of pyemia is, no doubt, of the same indirect character. In all wounds, and in injuries with unbroken skin, if sufficiently extensive, there is a certain amount of traumatic fever present, and in this state the bioplasts of the blood and injured tissue are already degraded and multiplying too rapidly, and a small additional noxious influence will further degrade them into infective graft-germs; while, at the same time, the vital resistance, described at § 12, is lowered. The presence of any notable amount of bacteria, and the consequent putrefaction of non-living matters in the wound, is such

On the other hand, no plausible conjecture ever has been put forward for the origin of specific parasites. Thus we may take it as proved, by experiment and observation, that altered living matters, here called graft-germs, do exist, and are capable of explaining the phenomena of contagion equally, as respects viability with the parasitic germs, except on one point. The exception is the power of growth and multiplication in indifferent media out of the body. Supposing we allow it is sufficiently proved that graft-germs can retain

an influence, and a most powerful one; when, therefore, this occurs in ill-tended wounds, infective pus or graft-germs form, which, either at once or after passing from one patient to another, acquire the virulence of the hospital pyemic infective poison. But the growth of bacteria, and the noxious influence of the chemical poison secreted by them (sepsin.), is not the only cause of pyemia, hence "the antiseptic method" hardly designates correctly Professor Lister's admirable and successful mode of treating wounds. It is generally admitted now that the total exclusion of bacteria is not necessary, nor is it attained by the spray during operation, and the impervious dressings after. Bacteria have been found in the best dressed and quite healthy wounds; and Billroth and Ehrlich found no difference in the putrefaction of blood drawn directly from an artery and sealed-up under spray, and that without such protection; the spray did not either keep off nor destroy the bacterial germs. Besides, if mere bacteria acted as a pyemic poison as self-reproducing, and in minimal dose, like the poison of rabies, syphilis, and smallpox, nobody could survive the smallest cut or abrasion, and vaccination and subcutaneous injection would be certain death. It was proved experimentally by Dr. Roberts (*British Medical Address*, 1877, p. 25) that the ordinary dose of morphia solution for subcutaneous injection, caused speedy putrefaction in sterilized beef infusion, just like any other septic germ inoculation. So it seems generally agreed that good surgery with the open method, where that is practicable, is quite as successful as the Listerian method, except in hospitals. And for the same reason, viz., that the bacteria are kept from multiplying *in quantity sufficient* to produce fever and inflammation, leading to degradation of the bioplasts and formation of graft-germs, and thus *originating* the infective poison. The true explanation of the action of the carbolic acid or other antiseptics is, I believe, that given by Dr. Beale, viz., that, besides, of course, preventing the growth of bacteria, they stop the formation of pus, and with it the further degradation of the bioplasts into more virulent infective graft-germs. It is, in fact, an abortive process. The question is different where this poison has been fully developed, and clings to the surroundings of an hospital patient. Here the most fastidious

their vitality in moist and dry media as long as the contagia are known to do, and allowing that pus-corpuscles can grow and multiply in milk, serum, &c., as shown by Dr. Beale, yet we require more experimental evidence that they can be propagated in that way to the extent that the bacteria can be. For example, in Dr. Klein's* recent experiments on the organism found in the pneumo-enteritis contagiosa of pigs, it was found that a needle-point of the virus kept in a closed cell with a drop of pure aqueous humor for twenty-four hours, multiplied and grew. From this successive generations were cultivated, each time with only a small fraction of the drop. From these generations, up to the eighth, successful and fatal inoculations of animals were made. The author concludes, from these experiments, that the contagium resides in a different variety of the *Bacillus subtilis* from that which causes the splenic fever, and that this disease belongs to the category of physiologically specific parasitic diseases. Unless, therefore, it can be shown that graft-germs can be propagated to the extent above noted, out of the body, and might, therefore, have been the real contagium present at the same time as the bacilli, it is

precautions of the Listerian method cannot be called exaggerated, for we have to deal with a true morbid poison, which acts in minimal dose. And it is exactly here, in old, ill-constructed hospitals, that the greatest triumphs of the method have been won. The process is here, if perfect exclusion fails, almost purely abortive (like, in fact, the cautery to the bite of a rabid dog), and little, if at all, antiseptic, unless the theory be true that the poison consists of physiologically specific bacteria. Against this is the fatal objection that the specific poison may arise *de novo* in single isolated cases—thus, in far too short a time for the evolution of a new species of bacterium. The conclusion of Billroth is substantially that of Beale, that the specific poison is formed in the system, and does not reside in bacteria. But he calls it (*Coccobacteria Septica*, p. 166) a "phlogogenic ferment," or "phlogistic zymoid." No doubt the diseased part may secrete many noxious matters, and some may be ferments, but the specific poison cannot be a ferment, for, as said (§ 4), no chemical ferment reproduces itself, nor does it cause a living body to secrete more of it.

* *Quarterly Microscopical Journal*, April, 1878.

difficult to resist the conclusion that the latter was the true cause.

There is nothing *a priori* unreasonable in the supposition that bacilli should produce splenic fever or pneumo-enteritis just as the *Bilharzii Hæmatobium* is the cause of Egyptian dysentery; and I do not think Dr. Beale is justified in refusing to admit the physiologically specific parasitic as a possible category of contagious diseases, although I do not think it yet quite settled whether the three diseases admitted into it in the diagram belong to it, * although, as said, the

* The experimental proofs tracing special contagia to particular parasitic saprophytes, even the cultivation experiments, although strong, have been trusted to too much, as there are still several sources of fallacy which have not yet been obviated. For instance, Dr. Klein believes that, by his cultivation experiments, he has proved that the specific virulence of the pneumo-enteritis contagion lies in the bacilli rather than in the bacterium termo, both of which he reports as present, and he seems to assume there was nothing else present in which it could lie, notwithstanding the evidence of Lewis and Cunningham, and many others, that there exists an animal poison in peritonitis not bacterial at all. From my experience with putrefactive fluids, I should say the difficulties are much understated and not at all met by Dr. Klein. In transferring a drop of infective peritoneal secretion to the microscope stage we should see, with a comparatively low power, not only *B. termo* and *Bacillus subtilis*, but a number of other globe and chaplet bacteria, and varieties of rod and screw bacteria, besides granular matter and masses of germinal matter capable of growing and multiplying. With higher powers we should, in addition, see multitudes of finer globe-bacteria and amorphous particles of germinal matter, and we have reason to believe, beyond these again, exist bacterial germs and germinal particles totally invisible to our present microscopes. Dr. Klein admits the difficulty of separating the *B. subtilis* from the *B. termo*, and says nothing at all about the rest. From my experience, it is impossible, without further processes than he describes, to separate the different objects above named, and therefore I have no doubt that in his final cultivation, wherein he supposes he had nothing but *B. subtilis*, that he had also abundance of *B. termo* and globe-bacteria, besides germinal matter, here called graft-germs, in addition to other bacterial organisms of which no account is taken. I hold, therefore, that until he has excluded the possible action of the termo and globe-bacteria, he has not proved the virus to reside in the bacillus; nor till he has excluded the graft-germs, to reside in a parasitic organism at all. How this is to be done it is difficult to divine, for both are non-dialysable, and both are killed pretty nearly by the same

mode of development of the contagium out of the body is in favour of the supposition for them, as well as possibly typhoid and cholera, if an organism peculiar to them should hereafter be discovered. On the other hand, the impossibility of propagating smallpox, vaccine, and other contagia out of the body, tells more for the graft theory, although it is not decisive against the parasitic, for many parasites cannot thrive without their proper nidus.

§ 20. Here we strike upon the much-vexed question, "What is an individual?" If these bioplasts, or masses of degraded living matter, can not only be transplanted and live, and propagate themselves by fission in the solids and fluids of higher living beings, but can do so even out of the body altogether in indifferent pabulum, how do they differ from the independent species we call parasites?

On this subject I think we cannot do better than follow Häckel, according to whom absolute individuality does not exist in animate nature, but only relative; and that the whole of organic nature may be arranged into different orders or categories of relative individuals. Of these orders he makes six, and among them man and kindred organised beings occupy the fifth order, viz., Prosopa or Persons. A person or prosopon is not a single homogeneous vital unity, but is built up of a number, harmoniously arranged, of all the previous orders of individuality, and during the embryonal stage passes through all these lower orders in the course of its development. The first or fundamental order of which all the rest are constructed consists of cells, more or less

things. So let no one think the question is so easily settled. At the same time, although pus-corpuscles multiply in indifferent media, yet, as above said, more evidence is wanted that naked protoplasmic particles, like graft-germs, can survive the treatment which bacillus spores can. But is it not possible that extremely minute graft-germs may be shut up in bacillus spores? They are small enough; and some fungus spores are known to be shut up in ova.

complete, or protoplasam-masses, called by Häckel plastids, of which, specifically differentiated and combined, tissues and organs, symmetrical parts, and prolongations constituting the different orders are formed, and these together make up individuals of the fifth order or Persons. When these are connected by a common circulation and nervous system with unity of consciousness, and descended from a single ovum, as the offspring of two parents, the result is one which we have no difficulty in recognising as an individual, and to which we indeed apply the term of individual proper, and from which we take our ideas of individuality, and endeavour to apply them to organic nature as a whole, though with but indifferent success. For, not to speak of the absence of a nervous system and of consciousness in plants, the plastids of our different tissues and organs still retain their specific kind of vitality, and form, in fact, subordinate individualities in each person. Now, the greater the perfection of an organism the more are the separate individualities subordinated to the whole, and thus incapable of maintaining a separate existence. Consequently, in the mammals it is only in the order of plastids, and the lowest type of these, that we can expect to find a power of separate life for a time after detachment from the organism as a whole. For to each morphological or anatomical order of individuality corresponds a functional or physiological individuality, which enables it to sustain its existence independently, and manifest its vital activity. To the physiological individual Häckel applies the convenient term of *Bion*. Besides the *actual bion*, or mature physiological individual, and the *virtual bion*, or immature form, there exists a third form of bion, in which it can maintain its existence as an apparent independent bion for a longer or shorter period after separation from the complete physiological individual, without, however, being able to develop itself into an actual bion. This is termed a *partial bion*. The partial

bions, belonging to man and kindred animals, are chiefly the white blood and the lymph-corpuscles, the mucus-corpuscles, and the epithelial cells, and more particularly the spermatozoa, which, in fact, do not begin to perform their proper physiological functions until they are detached from the actual bion. There exists, therefore, already a biological category into which the degraded bioplasts or graft-germs naturally fall. They are, in fact, *partial bions*, produced either by degradation or disease of the healthy partial bions, or by the conversion of the fixed plastids into partial bions by degradation or disease. *

* Häckel distinguishes six orders of individuality, each of which is represented both by an anatomical or morphological individuality, and by a physiological individuality. His definitions of these are as follows:—"A morphological individual, or form-individual, or organic form-unity, means, as a general expression, that particular form-phenomenon which forms a self-contained and formally continuously connected whole; a whole from whose constituent parts none can be taken away or asunder without destruction of the essence and character of the whole form. A form-individual is, therefore, a simple connected magnitude in space, which, at the moment of judgment, we must regard as an unchangeable figure."

"A physiological individual, or functional-individual, or vital-unity, is that particular form-phenomenon which is capable of maintaining its own existence quite independently for a longer or shorter period; an existence which expresses itself, in all cases, in the activity of the most general organic function, in that of self-preservation. The functional-individual is, therefore, a simple connected magnitude in space, which is observed to live as such for a longer or shorter time, *i.e.*, that can nourish itself, and which, at the moment of judgment, is to be looked upon as variable. Very often the same may, in addition, propagate itself, and perform other vital functions. For shortness, let us once for all give to the physiological individual the name of *Bion*."

Both the anatomical and the physiological individualities occur in nature under six different categories, or *orders of individuals*, as follows:—

I. Plastids (cells and cytodes, or elementary-organisms).

II. Organs (cell-stocks or fusions, simple or homo-plastic organs, composite or hetero-plastic organs, organ-systems, and organ-apparatus).

III. Antimers (counterparts or homo-typical parts, rays of the radiata, halves of the bilateral symmetrical animals, &c.).

IV. Metamers (prolongations or homo-dynamic parts, "internodes" of the phanerogams, "segments," rings, or zonites of the articulata and vertebrata).

§ 21. A clear distinction being now made between parasites and detached living particles of higher organisms, let us see how far the theory of graft-germs, or partial bions, fills up, and how far it shares, the defects of the parasitic germ theory. Partial bions are particulate, living and propagating rapidly by subdivision and growth, thus sharing equally with parasitic germs in the power of explaining the chief property of contagia. Besides, they are actual portions of a diseased body, and are formed by degradation or disease of it, and thus can subsist in a great variety of shades of

V. Persons or prosopa (shoots of plants and cœlenterata, &c., "individuals," in the strictest sense, in the higher animals).

VI. Cormi (stocks or colonies, trees, shrubs, &c., composite plants, salpa-chains, and polyp-stocks).

All these orders are represented throughout animate nature, on the one hand, as independent beings, and on the other, as built up into each other, the lower into the higher, to form the compound orders of individuality, of which all above the first consist, and each of the higher contains all of those orders below it.

The first order, or plastids, is represented as independent organisms, which never rise higher by most of the protista and many algæ, such as amœba, actinophrys, the so-called unicellular organs, including even the gigantic caulerpa, bryopsis, &c. Within the higher orders the plastids form, of course, the basis of all the parts of which they are built, and are represented by the protoplasm-masses, or bioplasts, or cells, to which alone the protoplasmic theory of life restricts the possession of vitality.

Order II. is represented by many independent species of protista, algæ, and cœlenterata.

Order III. The antimer-state is hardly represented in nature as independent, excepting the larva-state.

Order IV. The metamer-state is largely represented in nature by most of the mollusca and many worms and algæ.

In the higher orders, "the organ, in its purely morphological sense, is a complex of two or more united plastids. The antimer or homo-typical part is a complex of two or more united organs. The metamer or homodynamic part is a complex of two or more united antimers."

Order V., or persons, is a "complex of two or more united metamers." It is represented by the majority of the higher animals, but by few plants as independent beings. On the other hand, the majority of plants and cœlenterata reach the stage of persons, but cannot exist so independently, so they form Order VI., viz., the stock or cormus, which is a complex of two or more united persons.

difference, and originate *de novo;* they consist of amorphous protoplasm, which may have every variety of power while apparently identical in physical aspect; their specific power is developed with rapidity. In all these respects the graft-germs have the advantage of the parasitic germs in explaining the phenomena of infectious diseases. But beyond that, as long as they are merely transplanted and increase solely by the subdivision of the actual particles originally conveying the infection, then they must share the defects of the parasitic theory.

It is stated by Dr. Beale, as his deliberate conclusion, "that the millions of contagious particles produced in the

The physiological individuality which corresponds to the above six orders may itself consist of three different kinds, so there are thus eighteen possible organic vital unities to be considered. The three kinds are :—

I. "The *actual bion*, or physiological individual in the strictest sense, is each completely developed organic individual which has reached the highest degree of morphological individuality which belongs to it, as mature full-grown representative of the species. For example, the actual bion in the phanerogams is a morphological individual of the 6th, in the vertebrates of the 5th, in the majority of mollusca of the 4th, in the spongiæ of the 3rd, in the volvocinæ of the 2nd, and in the unicellular algæ of the 1st order.

II. "The *virtual bion*, or potential physiological individual, is each undeveloped organic individual, so long as it has not yet reached the highest degree of morphological individuality which belongs to it as a mature full-grown representative of the species, and to which it can develop."

III. "The *partial bion*, or apparent physiological individual, is each part of an organic individual which has the capacity, after detachment from the potential or actual bion, of surviving a longer or shorter time, and continuing its existence as an apparently independent bion, without, however, being able ever to develop into an actual bion."

The partial bions generally perish after a time, during which, however, they may have exercised a determinate function (*e.g.*, reproduction); as, for example, is the case with the hectocotylus of the cephalopods (an organ), with the proglottis of the cestodes (a metamer), with the male flowering shoot of the vallisneria (a person)." The white blood corpuscles of animals, and the cells of the spongiæ and other amœba-like plastids, often continue to move after separation from the organisms to which they belonged. And, according to Recklinghausen, even the blood-cells of the

organism in an eminently contagious disease, are all the direct descendants of the very few, or perhaps even single particle, first introduced."* He positively rejects the idea that the morbid action and the multiplication of the disease-germ are the consequence of the peculiar influence of the disease-germ on the healthy living matter. Hence, the graft-germ theory, as far as interpreted by Beale, is open to all the objections to the parasitic germ theory given at § 15, and which need not be recapitulated. And, in addition, all diseases caused by disease-germs ought to be contagious, whereas the whole large class of the purely miasmatic are not. (§ 24.) Further, although excessive action of the common stimuli and pabulum may easily be conceived to hurry on vital activity so as to cause degradation of the bioplasts into pus, yet mere growth by self-division in different media can hardly explain the rapid gain of specific virulence by successive inoculations, without some other influence such as spoken of at § 28, p. 62. I conclude, therefore, that although it explains the first batch of animal graft-germ diseases on the diagram much better than the parasitic-germ theory, yet it quite fails in the specific fevers which follow next. Besides, can we really imagine that in diseases that are known to have existed for centuries, such as smallpox, all the countless millions of graft-germs are derived from mere subdivision

higher animals can, under favourable circumstances, not only survive out of the body, but even multiply and go through determinate changes. The ciliary cells, also, of many, especially the lower animals, continue their movements for long after detachment. Many plant-cells, when detached from the parenchyma, can live for long, and even multiply by fission, without being able to develop into actual bions. The pollen grains of the phanerogams possess a high degree of physiological individuality, and most of all the zoosperms of the cryptogams and the animals. The physiological activity of partial bions is even more completely illustrated by those belonging to individualities of higher order, but it is chiefly those of the order of plastids which interest us here.—See Häckel's *Generelle Morphologie*, vol. i., chaps. 8 to 11.

* *Disease Germs*, p. 191.

of the single particle, or few particles, which were first differentiated? It is contrary to experience that fissiparous generation should continue perpetually in independent species, but some other mode of generation must intervene at intervals. Much more is it against the nature of partial bions, which are the true physiological analogues of the disease germs. Their duration is always temporary, and although it is stated by Darwin that the male reproductive element is "enabled to keep alive for four or five years within the spermatheca of a female insect," yet that is an extreme case, and the most we can expect from partial bions is that they should have a power of survival equal to what is known of the contagia. There can be little doubt, therefore, that the partial bions of contagion take a new origin from co-operation with the previously healthy blood or tissue-protoplasm of each subject of the disease.*

§ 22. The partial bions of the specific fevers thus fall into the category of *specific stimuli*, *i.e.*, they excite in the healthy parts an altered vital action, which constitutes the disease. They are, therefore, only one factor in the process which results, among other things, in the secretion of matter of the same nature as themselves. By their action as specific stimuli may be explained some of the phenomena not so well, if at all, explicable by either the parasitic or the simple graft-germs, such as the different intensity of the same morbid poison on different individuals, the elective affinity of organs or tissues, the immunity from second attack, and partly the relations of the latent stage; for all positive agents act as stimuli on the living matter—not only as functional excitants, but as modificators of nutrition—each in its own specific

* This was substantially the opinion of Jenner in respect to smallpox, and it has been confirmed by the best observers since, whose opinions are summed up by Dr. Braidwood, who says we must "acknowledge that the variolic virus generated by an animal is not the same as that which was introduced into it." (*Morphology of Vaccine Lymph*, 1874.)

way, and for which the living matter has a corresponding specific irritability or susceptibility. This specific irritability is proper to each organ and tissue; hence the elective affinity of all medicines and poisons each to its proper seat. The degree of specific irritability differs in all individuals; hence the different degree of intensity of action of the same poison on different individuals. All irritability is liable to exhaustion by excess of action of stimuli; and most varieties of specific irritability may be diminished or lost, at least for a time, by the action of their corresponding stimuli, while the power of reacting with other stimuli remains. Thus is explained the influence of use and wont, whereby many things at first highly pleasurable or painful become by repetition blunted in their operation, and finally indifferent. By these principles is explained the law of immunity from a second attack of the specific fevers, which is quite unintelligible on the parasitic and simple graft-germ theories. Only the morbid poison has a much more complete effect in that direction than the ordinary chemical poisons; still this is merely an exaggeration of what pertains to the action of all stimuli. In favour of this being a question of stimulation, and not altogether belonging to the more mysterious quasi-sexual function of the partial bions, to be alluded to presently (§ 23), may be noticed, that not only does vaccine matter, which is a modified smallpox partial bion, protect against the latter, but Belladonna, which is merely a chemical stimulus, protects, though temporarily, against certain types of scarlet fever to which its action is the pathological *simile*. Likewise, a latent stage is found in the action of nearly all poisons, and even medicines, and some light is thrown on the mysterious connection between the length of the latent stage and the severity of specific diseases by the general principles of the action of stimuli. For it is laid down as a law deduced from observation by Fletcher, that,

ceteris paribus, the severity of the disease is in proportion to the length of the latent stage. This is supported by the action of ordinary stimuli. "If a pinch of snuff be received into the nostrils, the excitement which it occasions is short, the collapse and increased secretion are slight and soon over; but if a similar pinch of asarum be received, the excitement lasts for some hours, during which we are not conscious of any effect, but the collapse and increased secretion which follow are proportionally severe and of long duration; and it is a remark very frequently made with respect to common catarrh, that the sooner it displays itself after the exposure to its exciting cause, the less violent it is and the sooner it is over. * Of course the *ceteris paribus* must be rigidly kept in mind, otherwise the exceptions may easily appear more numerous than the rule. The author is less happy in the alleged cause of the shortening of the latent stage by inoculation of small-pox matter, when he says, "that in its concentrated state it produces so strong a contraction of the capillary arteries as is incompatible with a long continuance, and the subsequent relaxation in which the disease consists is in proportion to this continuance." (p. 136.) Too much stress is here laid upon the mere capillary constriction and dilatation which doubtless make up one factor in all inflammatory and febrile diseases; but, nevertheless, in a specific qualitative change in the living matter which in a certain time exhausts the susceptibility to the specific stimulus producing that change, it must be of consequence to the result to shorten that time wherein the morbid influence acts. As a matter of fact, however, we do not know whether the concentration of the virus has the effect above assumed, nor how it spreads from the focus of infection. On this subject Dr. James Ross has some ingenious suppositions which deserve attention,

* *Elements of General Pathology*, p. 88. MacLauchlan, Edinburgh, 1842.

although they are as yet only hypothetical.* In favour of Fletcher's law, though not of his explanation, is the fact that when inoculation succeeded in propagating scarlet fever, the latent stage was not shorter, and the disease not milder.

§ 23. Still, the action of the partial bions of the specific fevers as specific stimuli does not explain the reproduction of secretions like themselves as the outcome of their operation, although this is obvious and intelligible with both the parasitic and the simple graft-germs. Hitherto we have had a solid bases of facts to rest on; there are parasitic germs, and there are partial bions, which may act, some as graft-germs and others as specific stimuli, and we have legitimate grounds on which may be discussed the propriety of arranging particular diseases in one or other of these categories; but now we must enter on hypothetical ground, and trust to inference and analogy for further elucidation of the subject. So much must be said not to prejudice what has gone before.

As a rule, the material stimuli consist of non-living chemical substances; and, during their operation, they become incorporated with the living matter, exalting or modifying its vital activity, while they themselves are decomposed, or enter into new combinations and are eliminated. On the other hand, foreign living matter coming into contact with that of any organised being is generally destroyed and decomposed, being consumed as pabulum, or acting as a dead stimulus. But there is a conspicuous exception in one of the partial bions to analogy with the physiological action of which we trace the nature of disease-germs, viz., the genital element, whose function it is to blend with other living matter, without being destroyed in the process, but, on the contrary, to form with it a new modified living being, which shall run a fresh life-cycle. We may imagine that the cause of death of all individuals is the gradual loss of the germinal

* *Graft Theory*, p. 128.

faculty, which may consist in a certain energy of position of the ultimate elements of the complex living matter, during its self-renewal by interaction with the environment which constitutes life. None of the external conditions, including pabulum and non-living stimuli, can apparently restore the energy of position proper to youth, hence decay and death of all living beings. But the interaction of two somewhat different kinds of protoplasm upon each other can do this, as we see in the process of reproduction. Hence the incomparable power of living matter above all dead stimuli and conditions as modificators of the germinal faculty; and could we only find this in disease-germs it would explain both their tremendous power and their reproduction.

Such is the theory of the quasi-sexual operation of disease-germs. The first intimation of this, in my recollection at present, is by Trousseau and Pidoux, where they compare the taking of a contagious disease to *conception*, and the idea has been more or less frequently present to pathologists since. It is alluded to by Dr. Beale in these terms, while, however, he rejects it for the alternative given at § 21 :—"It might be maintained that the contagious material actually passing into certain portions of the living germinal matter of the organism excited in these new actions, and caused them to divide and subdivide very actively, and communicated to them the same properties which the original particle possessed, somewhat in the manner in which the wonderful powers existing in connexion with the germinal matter of the spermatozoa are communicated to that of the ovum, and affect, to some extent, every one of the multitudes of living particles resulting from its division." * Since Dr. Beale's alternative is so inadequate and unsatisfactory, it may be well to reconsider the one he rejects. In the first place, as we are dealing here exclusively with plastids of the first or

* *Disease Germs*, p. 188.

lowest order of individuality (§ 20), we have not to look for visible distinction of sexes. In independent individuals of this order, for the most part, either no sexual differentiation is found, or both sperm and germ-cells belong to the same individual. Nevertheless, we cannot say that any species can persist without sexual generation occurring in some part of the cycle of their life-history. According to Häckel's definition, "the criterium of sexual generation is the material union of two different generative substances," and this is equally fulfilled by the process of conjugation proper to the lower orders of animate beings, whether the sexual elements are preceptibly differentiated or not. Asexual generation is represented in external nature by fission or fissiparous generation and by spore-formation. Of the former there are two kinds, viz., simple division into two parts of equal age, and budding, in which a portion grows out, and is then detached, forming a product of different age. These processes are known to occur in partial bions, as we see in pus-corpuscles, which are the simplest type of disease-germs; hence, no doubt, Dr. Beale is so far justified in limiting his theory of disease-germs to those whose mode of propagation is proved, and to extend it further carries us into the region of hypothesis. Still, hardly any hypothesis could appear more marvellous and improbable—were we not familiar with them—than the phenomena of infection still unexplained by him. Asexual spore-formation has not been proved to occur with partial bions, otherwise that might account for some of the facts of long survival and dormancy of miasms. It is in the various forms of conjugation that we must hope to find analogies with the process of infection. In conjugation, a more or less complete blending of the protoplasm of two individuals, which apparently do not sexually differ, takes place. The result of this is the formation of what are usually called spores [zygospores], but which De Bary and

Häckel consider to be impregnated ova, because they are preceded by the essential condition of sexual generation, viz., the union of two separate portions of living matter. It is immaterial that the genital elements are not differentiated, but diffused through the whole protoplasmic mass. Häckel thinks it a probable supposition that some such separation of the different elements has already taken place in each plastid, and that conjugation is thus in reality a mutual impregnation of two hermaphrodite individuals of the first order—a phenomenon which is the rule in hermaphrodites of higher orders, such as snails.

The form of conjugation characterised by complete blending of the two plastids into one, followed by its total breaking up into spores, as occurs in gregarinæ, and rhizopoda and some infusoria, can hardly be represented in the process of infection, except possibly in those gland-cells which are destroyed in the disease, as is the case with many tonsillary glands in scarlet fever, and certain mucus-glands of the intestine in typhoid. This destruction of glands is used by Dr. Maclagan *—a partizan of the parasitic theory—to explain the immunity from second attack, inasmuch as these parts form the special nidus of the parasite, and when destroyed, it can find nowhere to lodge in a second time. This theory goes only a small way towards explanation of the immunity; but, as far as it goes, the conjugation of partial bions fits better than the lodging of parasites.

In the incomplete form of conjugation there is merely adherence at some point, and partial blending of the protoplasm of the two plastids, while the individuality of each remains more or less complete. This occurs in Desmids, Zygnemaceæ, and some infusoria. Rejuvenescence is another process in which change without destruction of the cell-contents takes place. This, till lately, has been limited to a

* *The Germ Theory*, by Dr. T. Maclagan. London, 1876.

change in the cell-contents of the Œdogonium and some other low plants, whereby they are converted into swarm-spores; but Bütschli has recently extended the significance of the phenomenon. It is supposed that in rejuvenescence of single cells a differentiation takes place in the contents of the single cell, and the different parts blend, and hence a new departure in reproduction is taken.* Conjugation of two separate cells as a prelude to rejuvenescence is, Bütschli† thinks, seen more plainly in the bacillariaceæ, but it is not followed by coalescence of the two cells, and formation of a zygospore or a sporangium, as in ordinary conjugation. On the contrary, the cells become larger and more vigorous, and a rejuvenescence has taken place. Bütschli, in fact, considers the conjugation of these and several species of infusoria, up to the rank of paramecia, to be a prelude to rejuvenescence, and a fresh departure of merely fissiparous generation, without the formation of any true sexual products. As a matter of fact, I believe it will be shown that he is wrong in respect to the paramecia in which the formation of spores after conjugation does occur. But that conjugation, as a quasi-sexual process, is followed by increased reproductive vigour, without destruction of the cells, *i.e.*, rejuvenescence, is probably to be accepted as a natural process. We have thus in external nature, in conjugation and rejuvenescence, a parallel to the process of infection, which may thus be looked on as the quasi-sexual stage, which is interpolated in the life-history of all species, as it occurs in disease-partial-bions. The rejuvenescence will probably tell more on the floating partial bion than on the fixed plastids, with which a kind of hybrid is formed and cast off; but it may also tell on the fixed plastids, modifying them so as to produce the immunity,

* Archer. *Nature*, 13th June, 1878.

† *Studien über die ersten Entwicklungsvorgänge der Eizelle, die Zelltheilung und die Conjugation der Infusorien.* Von O. Bütschli. Frankfurt, 1876.

and possibly other changes, not necessarily for evil. For the powerful stimulus of living matter may restore the germinal faculty if weakened or degraded. It has been noticed that in cases which recover from the specific fevers (if not prevented by sequelæ, in the form of local inflammations, etc.), an unwonted vigour of health sets in, and specific tendencies to disease are overcome; *e.g.*, the tuberculous diathesis is said, at times, to be extinguished after typhoid fever. I have read also of a case in which the susceptibility to smallpox was regained after typhoid fever. These facts gives us a hint of the possible use of the morbid poisons as therapeutic agents.

As before said, we have no actual proof that partial bions can be reproduced in any way except by fissiparous generation; but the above mode of reproduction, if applicable to them, might suffice to explain the cardinal facts of the specific fevers. The last word of science is not spoken; other modes of generation in external animate nature may be discovered, and partial bions may be shown to be capable of the above or other modes of reproduction. In the meantime, we may conclude that all action of living matter, as a stimulus, has a strong analogy with the quasi-sexual processes. In this we may probably find the explanation of the remarkable increase of virulence by the successive inoculations of diseased partial bions, described at § 18. The union of these with the similar, but somewhat different, fixed plastids, may be compared to the effect of intercrossing in fully sexually-developed species; and an increase of vigour takes place till a certain acme for each specific disease-germ is reached.

§ 24. In transplantation of plastids combined into tissues and organs, forming the second order of individuality (§ 20), as when a piece of skin is grafted, it becomes attached to and nourished by the new person, and is now as much a

piece of his skin as it was of the old person's; it does not affect the neighbourhood except by contiguity and nerve-attachments. So also in transfusion of blood, no doubt the partial bions of the first order, the living corpuscles, simply continue the same function in the new person as they performed in the old, and no disturbance arises where their quality is nearly identical. But when a slight alteration has taken place by disease, even the healthy plastids may act as living stimuli. This is probably what takes place in that modification of skin-grafting for the cure of ulcers, wherein they are sprinkled with the mere scrapings of healthy cuticle, containing small particles of still living epidermic protoplasm, or with the fluid of a blister containing such. The latter, no doubt, blends, while remaining still living, with the protoplasm of the open sore, and exerts a quasi-sexual stimulation, which restores their full germinal power to the weakened plastids of the ulcer, and enables them to form healthy skin. A similar effect, beyond mere transplantation, is seen in grafting among plants; and the affection of the stock by the scion after grafting attracted the attention of Mr. Darwin—whose genius has given the impulse to a new departure here, as it has in almost every branch of biology—and induced him to compare such affection to an inoculated disease in the case of animals. This probably attracted the attention of Dr. Ross, and became the exciting cause of his book on the Graft Theory of Disease, in which he has collected a number of facts which support the theory of quasi-sexual stimulation rather than of simple grafting. A few of the most striking may be quoted. Mr. Darwin's words are as follows :—"It is certain that when trees with variegated leaves are grafted or budded on a common stock, the latter sometimes produces buds bearing variegated leaves; but this may perhaps be looked at as a case of inoculated disease." And again, "It is notorious that when the variegated jessamine is budded on

the common kind, the stock sometimes produces buds bearing variegated leaves. Mr. Rivers, on the authority of a trustworthy friend, states that sound buds of a golden variegated ash which were inserted into common ashes, all died except one; but the ash stocks were affected, and produced, both above and below the points of insertion of the plates of bark, bearing the dead buds, shoots which bore variegated leaves. Mr. Brown, of Perth, observed, many years ago, in a Highland glen, an ash tree with yellow leaves, and buds taken from this tree were inserted into common ashes, which, in consequence, were affected, and produced the blotched Breadalbane ash." *

Similar facts related by Dr. Masters are still more striking, for he states, on the authority of Mr. Rivers, that "an unhealthy or feeble stock has been restored to health by the imposition of a healthy graft." And again, "Cases have been observed where, from the stock *below* the graft, fruits and flowers of the same appearance as those borne on the scion have made their appearance. This has been observed in the case of the pear grafted on the mountain ash, and in other cases." And again, "The effect produced even by a temporary contact with the variegated bud, is confirmed by a case that fell under our own observation. A year or two since a beautiful *Abutilon*, with leaves mottled with yellow, was introduced into our gardens. It was very desirable that this should be propagated as largely and speedily as possible. Propagation by means of cuttings was easy enough, but naturally the plants were small, and took a considerable time to grow bigger. Grafting was therefore had recourse to. The scions of the variegated *Abutilon Thomsoni* were grafted on to green-leaved stocks of other *Abutilons*. This was done by many nurserymen on the continent as in this country, and it was soon found that the grafted plants were apt to produce

* *Animals and Plants under Domestication.*

variegated leaves from the stock; in other words, that the peculiar qualities of the scion were manifested throughout the entire organism. To show that the variegation was really due to the influence of the scion, we may mention a curious fact communicated to us by M. Van Houtte, the well-known nurseryman of Ghent. Like his compeer, he had plenty of illustrations of the fact that a variegated scion of this particular *Abutilon* will communicate its properties to the stock on which it may be grafted, but he further ascertained that if by some accident the graft were separated from the stock, the leaves subsequently produced from the latter were wholly green, as before the grafting, and even the variegated leaves originally produced lost their mottled character."* These facts have a wider bearing than may at first appear, for they lead us to perceive that the migration of partial bions, not only occasionally but permanently, may be one of the means of bringing about the unity of the individual of the higher and compound orders of individuality (§ 20), such as Persons. The somewhat overburdened nervous system cannot here be taken into account. Indeed, in animals we can no more expect the nerves to convey material specific properties than we could expect telegraph wires to carry goods as well as messages. Here, at least, we can only suppose that particles of the living matter of the scion are carried in the juices of the plant through the whole plant, and act as living stimuli on those parts, and on those only possessing a corresponding irritability or susceptibility, thus producing a marked alteration on the germinal faculty, but one which is apparently not permanent, as there is a tendency to revert to the original type unless the stimulus is kept up. This seems to be almost parallel to the influence of the development of the sexual organs at puberty in producing the change of voice, the growth of the beard, and a

* *Popular Science Review*, April, 1871. Quoted by Dr. Ross, pp. 42–48.

certain masculine character of the whole habit of body, which are all apt to fade away after castration. The sympathy by which these phenomena are made interdependent is generally attributed to stimulation conveyed by the nerves directly or reflexly to the secondarily altered organs or parts. But it is quite possible that they may be in great part owing to the continued action of partial bions which are thrown off by the testicles, and act as stimuli to the germinal faculty of the parts susceptible of this special influence. The same principle may probably be extended to many other evidences of the constitutional unity of character of nutrition in each person, who is yet made up of such a number of separate parts, each with its inherent specific vitality. For the influence of the separate parts on each other's nutrition can hardly be more palpable than the above examples in plants which have no nerves. The same principle extended to disease has probably even a wider scope, and we may thus comprehend the nature of certain so-called constitutional diseases which seem to be transferable from one part to another, and we may understand better some forms of metastasis and the nature of the evil effects of suppressed discharges. For although the reflex actions of the nerves of organic sympathy are really the cause, and suffice to explain the greater part of sympathetic morbid actions, still there are some not reached, more especially gouty metastasis and the evils of suppressed secretions. For, in spite of the efforts of dogmatic pathologists, the vulgar still retain the fear of "driving in the disease," inherited from the times of the old humoral pathology, and this fear is shared in by many thoughtful practitioners. Although, of course, on the protoplasmic theory, it is impossible that the liquid blood can be alive, and therefore absurd to speak of it as diseased, yet we must not look on it as a source of disease only as altered pabulum or the vehicle of noxious chemical stimuli, but as

containing particles of living matter which have most importtant functions in health, while similar particles in a diseased state may act as noxious living stimuli on the healthy plastids of distant parts, and thus convey specific diseases. This idea has recently received an important application in the theory of secondary cancer put forth by Dr. Creighton, and received with favour in the medical world.* The theory is that the secondary cancerous tumor is not caused by the transplantation of complete cancerous cells from the primary tumor, which take root in a different organ and grow there, but that it is produced by the transformation of the previously healthy cells of the organ—say the liver—by the operation of an extraneous influence, "which is to be compared to a spermatic influence produced in some unknown manner by the parent tumor." Thus the quasi-sexual operation of partial bions, or portions of living matter thrown off by healthy or diseased living tissues and organs, may have an extensive application within the body itself, and it is only natural to extend the same principle to the action of one body on another in explanation of the nature of contagious diseases.

I conclude, therefore, that an assumption of a conjugational or quasi-sexual power in the partial bions constituting the exciting cause of the specific infectious diseases would remove the objections applying to both the parasitic and the simple graft-germ theories, which tell especially in the fevers of the smallpox group. I propose, therefore, to add the term conjugation-germ to those already in use. (§ 17.)

To go into the detailed application of these principles to the infectious diseases in general is impossible, as my space is nearly exhausted. A few words only on their applicability to the clinical facts of the smallpox group, which demand that the multiplication of the poison shall depend on the co-operation of the organism, and not on the self-multiplica-

* *Privy Council Health Reports*, 1874.

tion of a foreign organism merely sojourning within it. At the time of infection of smallpox we may imagine the conjugation-germs absorbed and diffused in extremely minute subdivision through the whole blood, whence they are speedily removed and blended with the fixed plastids specifically adapted to combine with them, for the blood, as a rule, does not convey the disease. In the latent stage, some unknown change, in addition to that which happens with all stimuli, is taking place, like the early stage of conception, which gives rise to few symptoms. Some, however, can be detected; for instance, wounds will not heal at that time. At the period of invasion the sudden and enormous reproduction of the specific partial bions from the infected fixed plastids begins, thus causing the initiatory fever. But the reproduction of the specific partial bions is not the proximate cause of the whole febrile symptoms; for the irritation of that process causes a large amount of the febrile disturbances which are common to all kinds of fever, including those arising from non-specific causes. We have the irregular distribution of blood from irritation of the vaso-motor centres (which though attracting most attention is less important), and, above all, the increase of the bioplasts of the blood and capillaries, which is the essential proximate cause of the febrile and inflammatory states. This is recognised by Dr. Beale, who points out that not all the abundant masses of germinal matter and bioplasts found in infective ophthalmia are the descendents of the infecting graft-germs, but many or most are simply the superabundant formation of non-specific bioplasts, which is the essence of inflammation and fever. This is important, as the non-specific part of the disease greatly complicates and aggravates the total result, and may be what determines the fatal event in particular cases. Besides therefore the varying susceptibility to the specific poison, we have the same variety

towards common exciting causes, for no two people suffer alike in degree from the common causes of disease, such as cold or other perversions of the ordinary conditions of health. Hence a double cause exists for the varying intensity of the total disease in different persons; and hence also the existence of a margin of possible success in treatment, even although we may not possess a specific antidote for the specific poison. Another subordinate complication of some specific diseases is the presence of saprophytic parasites, which may contribute largely to the severity of the total disease. Their relation to the specific cause has been already dealt with. (§ § 10, 11, 12, 13.) In some specific diseases we are probably concerned only with graft-germs propagating asexually; in others, especially those both inoculable and infective through the air, both kinds of germs must be taken into account. It is not yet clear how the conjugation-germs spread through the system from the point of inoculation, but certainly they are diffused everywhere before the specific secreting vesicle is complete. Bryce's test shows that the system is affected enough to influence the course of a second vaccination in a new place, before the original vesicle is fully developed. Therefore, the full development of the latter is not the cause of the affection of the system. It is quite possible, also, that the morbid poison in the form of graft-germs may be inoculated and grow asexually in the spot for a time, even when the system is protected—thus showing the difference between graft-germ and conjugation-germ-action. This probably takes place often in revaccination, for the percentage of cases in which a vesicle is formed exceeds those of liability to a second attack of smallpox. Vaccinators do not like to use that matter, but its specific efficacy has not been disproved. It is said that the old inoculators of smallpox sometimes kept up a supply of matter on their own arms.*

* *Germinal Matter and the Contact Theory*, by Dr. Morris, p. 67.

Similar principles apply no doubt to all the animal poisons which have a constitutional as well as a local action. Also the vegetable morbid poisons constituting Malaria must act as conjugation-germs, and the result of their union with the fixed or the blood plastids is no doubt an infertile hybrid, probably from the too great dissimilarity of the parent organisms. Hence the non-contagious nature of these diseases.

But it is impossible to pursue the subject further here, and I must be content to have given the above outline of an addition to Beale's graft-germ theory, and leave it to some future opportunity to follow out in detail the analogies of grafting, hybridization, need of intercrossing, etc., to the intricate processes involved in the infectious diseases.*

§25. In conclusion, let us pass again for a few minutes from matters of technical detail to the bearing of the principles here set forth on the general welfare of society, as affected by the fearful scourge of infectious diseases. The tendency of the foregoing has been to restore these diseases to the domain of medicine proper, in opposition to the parasitic hypothesis, fashionable for the moment, which would, as it were, consign them to a department of natural history. Were it so, there would be little hope of their extinction or mitigation by the medical art. On the other hand, if they are diseases bred within us from altered conditions of health, our prospects are better, though not unreservedly so. As long as infectious diseases, such as the catarrh and erysipelas group, arise from the operation of mere common non-specific causes, if by any chance they were swept clean out of the land, they would infallibly re-

* In fact, the subject forms part of a work on "The Stimuli," with which I have been engaged for some years. I may also say that since the printing of this paper was finished I have found that Dr. James Ross had already noticed the analogy between disease-germs and the partial bions of Häckel, which is satisfactory as a corroboration of the views independently given here.

appear, so long as poverty, dirt, overcrowding, famine, war, vice, etc., afflict the human race.

And with respect to the diseases of the class which now never arise except from infection, and whose origin is hidden in the night of time, although we may circumscribe the area of their operation by such means, yet we can never hope that good food, virtue, drainage, and ventilation will extinguish them altogether. as long as man is a social animal. That hope lies in the medical art, and, strangely enough, in the use of the very morbid poisons themselves whose tremendous power for evil has just occupied our attention. We have already two examples of the marvellous perfection as medicinal agents of these incomparably powerful specifics; and as it is contrary to the continuity of nature that there should be exceptions to any laws, these instances cannot stand alone. Our hope for the future must therefore be, by diligent experiment and research, to extend the same principle to all the fixed infectious diseases. The two examples alluded to are, one of protection against disease by the wonderfully perfect operation of vaccination; the other of cure, viz., of Pannus, by inoculation with the virus of purulent ophthalmia. Of the former it is needless to speak, as its merits are universally acknowledged; but the latter is little known out of the medical profession, so it may be described more in detail.

The word Pannus, which means literally a cloth, is applied to an opacity and thickening of the cornea like a cloth, producing blindness. It is characterised by a superficial vascular opacity of the cornea, due to the formation of a layer of new-formed cells beneath the epithelium, and in the superficial layer of the cornea, which becomes thickened and its surface rough and irregular. It is attended with great injection of the blood-vessels and sensitiveness of the conjunctiva and globe of the eye in general, flow of tears, intolerance of light, and more or less complete blindness. It

often remains as the consequence of the Egyptian or infective purulent ophthalmia, and is a fertile source of disablement of soldiers. It also arises from granular ophthalmia from whatever cause. When fully developed its cure is almost hopeless, all ordinary topical and internal medicines producing, at best, temporary relief, or none at all.

In 1812, Jaeger, of Vienna, discovered that inoculation with the matter of purulent ophthalmia, by exciting a fresh attack of that disease, had the effect of dispelling the pannus and restoring vision. As usual, we may unfortunately say in medicine, this was at first scouted and rejected by the profession, and Jaeger himself was discouraged, and ceased to employ the method till 1827, when Dr. Piringer * adopted and carried it out systematically with such success that, in 1841, of the one hundred and forty-five cases operated on by him and by Jaeger, one hundred and thirty-eight were cured. Since then it has been adopted into medicine generally, and is used especially with success in Belgium and England. The marvellous completeness of the cure by this operation strikes one with astonishment, and shows us that we are dealing with an agency far more powerful than ordinary medicines. One of the earliest cases in this country came under my observation. It was that of a young woman of twenty-one, who had been affected with granular ophthalmia and pannus since childhood; she was unable to count the fingers of a hand held up, had never learned to read, and was led about with bowed head, unable to bear the light, and the eyes running with a thin acrid discharge. A minute drop of matter from the eyes of an infant with purulent ophthalmia was, at my request, put into her eye by Dr. Dudgeon, now of London. In a few weeks the result was reported by him as follows :—"Instead of walking in the open air with her head bent forwards and her eyes scarcely open, she now walks

* *Die Blennorrha am Menschenauge.*

erect, and does not experience the slightest inconvenience from the brightest sunshine. She can see the minutest needlework, and is no longer dependent on the care and attention of others." * This is the rule: the eye is simply touched with the infective matter, and the disease allowed to run its course without the slightest medicinal interference, and with the above result. There is no fear of relapse, which constantly occurs after all other means of amendment.

In accordance with what is seen with smallpox, the inoculated disease is here milder than the purulent ophthalmia caught naturally, and the latent stage is shorter. (§ 22.) We find it also stated by Mr. Soelberg Wells,† "The matter from an eye suffering from inoculation is stronger than that from an infant [from which it is taken], as its activity appears to be increased by the inoculation." This agrees with what has been said at §§ 18, 23. In accordance with the principles set forth in the foregoing pages, the *rationale* of the cure by this method is as follows:—The plastids of the conjunctiva and cornea are in a state of germinal degradation, with so great a loss of formative power that they cannot produce the compact, transparent, healthy form of these tissues. Then the infective partial bions inoculated, unite with them, exciting a temporary increase of similar protoplasmic matter and profuse non-living secretion. When this subsides, the effect of the stimulus to the fixed plastids is seen in rejuvenescence, or regeneration of their full germinal faculty and formation of healthy tissue anew. (§ 23.) The result of this operation does indeed strike the observer as in reality a renewal of youth, or a new birth of the part. The tendency of the plastids in a state of germinal degradation, or, in fact, variation, to revert to their original state,

* See *London and Edinburgh Monthly Journal of Medical Science*, May, 1844.

† *Treatise on Diseases of the Eye*. 2nd Ed., p. 67.

which is the cause of spontaneous as well as all other cures, seems to be here wanting, even to the extent that ordinary medicinal stimuli specifically adapted fail to rouse it, and the more powerful stimulus of living matter (§ 23, p. 58) seems to be required. Here also in the cure we have an analogy with the influence of the scion on the stock in grafting, mentioned at § 24, p. 64.

With these splendid examples before us, one of the chief aims of medicine should now be to turn these fearful engines of power into agents of protection against, and cure of, the very evils produced by their uncontrolled natural operation. Or, in the words wherein the intuitions of the poet anticipate the reasoning of science,

> "Take thou some new infection to thy eye,
> And the rank poison of the old will die."

The path is already marked out for us. There is no chemical poison whose violence may not be effectually tamed by simple dilution, while its specific quality remains unchanged. That resource, of course, fails us with a poison which is reproduced by its very operation; but a similar result can be attained by passing it through the system of some other animal. For it is now established that the vaccine virus is nothing but the smallpox virus modified by passing through the cow. By the light of this knowledge, and guided by Fletcher's law of the relation of the latent stage to the severity of the disease (§ 22), let experimental research be pursued with unwearied perseverance, until the causes are found why those two examples of prevention and cure have so long stood alone, and success is attained in extending their number. Happy they who, with intellectual ability, have the leisure and the opportunity to devote themselves to experimental research directed towards this object. For some among them is, assuredly, reserved a place in the temple of Fame, beside the name of Jenner, as benefactors of the human race!

IS NATURE CRUEL?

By REV. H. H. HIGGINS, M.A.

Is Nature cruel? Answers in the affirmative might be gathered from writers at variance amongst themselves on almost all other points. There is indeed a very general impression that although certain poets, lovers of the beautiful, and enthusiasts of many descriptions, may be so carried away by their admiration as to see no imperfection in Nature; yet that, on the ground of intelligent and well-informed common sense, it is perfectly useless to deny that Nature is cruel, reckless, "red in tooth and claw."

By "cruelty" may be understood that which is exhibited in the infliction of needless and profitless pain. By "Nature" may be understood the total of all finite agencies and forces. By asking, "Is Nature cruel?" I mean, does the total of all finite agencies and forces reasonably appear to be characterised by the infliction of needless or profitless pain?

I am anxious to make it plain that by "Nature" I do not mean the Divine Being. In using the term "a speech" we do not mean "the speaker," though we may be confident that the speech does to some extent express the mind of him who utters it. Far more completely is Nature the expression of the One Great Mind, which does not act on Nature from a distance, but is immanent everywhere throughout the universe. Lastly, by "science" we may understand all that knowledge, of whatever kind, which is the result of well-regulated observation.

It would be disadvantageous to approach the examination of special occurrences supposed to be cruel in their character, but on which science may perhaps be able to throw some

fresh light, before alluding to some cognate enquiries which have perplexed the thoughtful in all ages. For example—How is it that pain and evil exist?

Do we think of what we mean when we speak of the banishment of evil from the universe? Where is the line to be drawn short of absolute perfection. Pain is supposed to be an evil, but without pain human life would be impossible. It is the pain of hunger that we shun in taking food; the pain of fatigue that prompts rest; the pain of injuries that compels us to take care of our bodies. Ignorance is an evil, but ignorance banished implies the boundless perfection of knowledge.

Apart from the Infinite One, we cannot conceive of good except as affected by degrees; and the lower degrees are by comparison evils. It is no limitation of the power of the Creator to say that we cannot conceive Him able to create light, as it is known to us, in such a way as that there should be no shade; or heat, as it is known to us, so as to exclude degrees of cold. This does not, as Leibnitz thought, imply an essential impossibility, or external fate, to which even the Creator must be subject; for this were nothing else than to adopt the old fallacy of personifying a negative and treating it as if it were an entity.

Admitting that the First Cause has willed the existence of something not Himself, we perceive that, on the accomplishment of that will, imperfection inevitably ensues. But the imperfection is not in itself an entity. If the production be a lifeless mass it will be subject to the conditions of matter; but incapacity of occupying two places at the same instant is not an entity, or a wrong. If the production be an animated, conscious, intelligent, energetic being, imperfection will in such a creature be liable to be displayed in a much more active and conspicuous form. But neither the lifeless mass nor the animated being can be conceived as competent to introduce

into Nature an antagonistic power. The imperfection implies that each lacks something; but imperfection does not involve a hostile agent; nor does it imply a limited power in the Creator.

It is replied that although this may be quite true for the existing state of things, why should there not be conditions wholly and entirely different *de novo?* We ought not to answer—Of course it is possible. How do we know it is possible?

Theologians admit that the Creator uses means to effect certain ends; for example, the happiness of man. It is affirmed that if this were the real object, and the Creator omnipotent, He had only to will the result in order to its accomplishment; and therefore, that contrivances, design, and the use of means, must imply a limitation of power in the Creator.

Let us see how the idea works. I want to make a young child happy, and I give him a piece of plum-cake, or a toy, and effect my purpose. But suppose that I wish to produce in the child a particular kind of happiness—the happiness of conscious success in learning a lesson and repeating it without a mistake. Can I produce this kind of happiness in any other way than by inducing him to learn the lesson? Surely not. Well, but I am an agent of very limited power. Suppose I were absolutely omnipotent, could I attain my end more directly? No, it makes not the slightest difference; the child must be induced to learn the lesson, or the joy of success could not be conferred even by an infinitely wise and powerful agent. We see, then, that when the nature of the end is duly considered, the use of means does not imply a limitation in the power that uses them. It may be replied that by an omnipotent agent the joy of success might be created without the preliminary difficulty having to be overcome. In plain terms, I should call this the sugges-

tion of a sham. I cannot deny the possibility, any more than the geologist can deny that the Creator may have formed the rocks with fossils in them which should appear as if they had once been living organisms. The argument must be left for those who can find any satisfaction in it.

But the moral question remains. Am I *justified* in inducing the child to undergo an irksome trial for the sake of the happiness which attends success? The child would probably say, "No;" especially if my inducements included a particular mode of discipline attended by pain. I am sure that the child could not appreciate all that I might know of the value of the desired result. He might call the infliction of pain cruelty. The child might say that if I could not accomplish my end by means more agreeable to himself, I was not fit to be his teacher. My *only* resource would be to wait in hope that increasing years and intelligence might bring him to a better state of mind.

As to the kind of happiness which may reasonably be regarded as appropriate to be a worthy object, we, who are being disciplined into its attainment, must necessarily be very imperfect judges. A village shepherd-boy thought that the height of happiness would be "to have a pair of well-oiled boots, and to swing upon a gate all day." We are wiser than he; but not immeasurably wiser. In pursuing the question —Is Nature cruel?—if we are to take the postponement of happiness, or the discipline tending to its attainment, as possibly implying cruelty, it becomes us at least to endeavour to possess the highest possible conception of happiness; and in the effort to attain such a conception our minds may change.

It does not seem possible to arrive at anything like a satisfactory understanding of the true aspect of those terrible natural calamities which from age to age fill the minds of men with horror and amazement, unless we are prepared to

lay great stress on the value of the *consistency* observable in Nature. Direful events of vast magnitude resulting, it may be, in the destruction of many thousands of human lives, are in their character appalling. What is our resource? It is a useful rule that we should judge a complicated question by the simplest case in which it is capable of being adequately illustrated. Consistency in Nature seems to authorise our placing a wide-spread calamity in the same category with a disaster such as may befall an individual. For an accident by which a single life is lost, or an individual incurs bodily suffering, is not *in kind* to be distinguished from a disaster which may be fatal to two or three or more lives, or which may bring pain and distress on a whole family or a tribe. Thus by almost imperceptible gradations we may pass from a mishap through which a workman may disable his hand to a catastrophe which may prostrate a whole nation. The difficulty lies in the supervention of pain and death innocently incurred; and when this happens on a scale of vast extent, as in the recent famines in India and China, we are shocked, and our faith in the beneficence of Nature is severely tried.

The enquiry, however, is open to us—Why should an individual, through no fault of his own, be liable to painful injuries, or even death? One reply may speedily be disposed of. It is not because Nature is cruel. No one believes that Nature is cruel because a man who falls from a high scaffold is killed, or because another dies who has swallowed poison. Let us conceive a state of things in which no such liabilities are incurred. For example, a man is rowing on a deep lake; his boat is capsized, and being unable to swim he sinks to the bottom; but he is not drowned, his lungs receive no oxygen, but his blood circulates as before, and he walks out along the bottom not a bit the worse for his submersion. If he could live without breathing, why should he

be supplied with his marvellous apparatus for respiration? The absurdity of the conception is only matched by the supposition that his drowning would imply cruelty in Nature. Here we have the advantage of a simple case which we can understand; but we have seen that a mysterious calamity, which we cannot at present fully understand, may in reality be a case of the very same kind.

The chief perplexities of many arise in connection with hurtful agencies of an extended character, of which we may especially mention four—pestilence, famines, storms, and earthquakes. In these many can find no extenuating circumstances; no plea in mitigation of a heavy sentence against Nature as guilty of gratuitous cruelty. To each of these four disastrous activities we may devote a brief consideration.

1. *Pestilence*, under one or other of its most malignant forms, such as smallpox, cholera, yellow-fever, and plague, has contributed to the history of human suffering some of the very darkest pages. In most cases the details are too horrible to be fully recorded; but they are well known; and when a fifth, or even a third, of an entire population has been swept away by an invisible hand, it is no wonder if that hand has been regarded as the hand of an enemy. Yet such a conclusion is incompatible with much that may be observed in the attack of a fatal epidemic. The wild denizens of the prairie or the forest, and the nomade tribes of the desert, are generally left unmolested. The evil commences, though it does not always stop, where men are closely congregated in large numbers, and have adopted a mode of life in which a degradation becomes possible, more pernicious than any which can prevail under other circumstances. The chastisement is fearful, but may not be excessive.

In a work entitled *Pioneeriny in South Brazil*, published in 1878, the author, a British engineer, speaking of Rio

Janeiro, says:—"Until the inhabitants themselves become more alive to the essential benefits of cleanliness, and practise this virtue with the same zeal which they devote to money-getting, the government will continue to have enormous difficulties to overcome in putting the general sanitary arrangements of the city into anything like a respectable condition. The state in which the hotels are kept, in certain essential points of cleanliness, is beyond all description disgraceful to the city. Though year by year yellow-fever, smallpox, and other loathsome diseases carry off their thousands, and permanently injure the health of thousands more, hotbeds of fever are allowed to remain, tainting the atmosphere and spreading death around."

If we turn from the West to the great cities of the East, we find matters even worse. A miserable superstitious fatalism paralyses alike the common people and the authorities to such an extent that in almost every decade a great wave of pestilence rolls forth from these centres of all uncleanness, searching out and reaching kindred spots, unhappily not altogether absent in our own country.

If we reflect on the impossibility of common morality in the midst of such pestiferous scenes, we shall admit that if Nature's stroke be heavy, it is needful. It enforces a decency which renders higher results attainable.

Then also must be taken into consideration that comparatively recent and most wondrous addition to physiological science known as the germ-theory of epidemic disorders; a discovery which holds out the hope of protection for our homes from maladies of a more domiciliary character, and illustrates with unusual clearness one great feature in all natural calamities—REMEDIABILITY THROUGH KNOWLEDGE.

Now, suppose that to escape from pestilence, and other evils of a like kind, we were driven to adopt courses tending to demoralisation, lowering us in our proper self-respect, and

repressing all our nobler aspirations—*that* would be indeed a hardship; *then* we might with truth exclaim, "O cruel Nature!" But when to avoid the deadly ills of plague and pestilence we have only to be wiser, and more cleanly, and more thoughtful for the good of others—let the sufferings from which we flee be ever so terrible—it seems unnecessary and unjust to speak of them as inflicted in cruelty.

2. *Famine.* We are able to form only very inadequate conceptions of the miseries attending scènes where thousands are daily perishing from want of food. Yet, with all its horrors, famine is the most obviously relievable of any natural calamity. If it were possible to predict the approach of rainless seasons a sufficiently long time beforehand, very much might be done to ward off the extremities of famine. Our knowledge is not yet advanced enough for this purpose, but it is making progress in the required direction. Help is probably at hand; but, marvellous to contemplate, it dawns from a most unexpected quarter. Men of science investigating the laws of magnetic disturbances, and watching the comparative prevalence or scarcity of dark spots in the photosphere of the sun, are able to announce a probable periodicity in seasons of extreme drought; thus commencing a science which may in the future effectually mitigate the sufferings of the human race from famine.

The prevalence of locust swarms has recently been shown by Mr. E. D. Archibald to be subject to a similar law of periodicity; and even events so far removed from ordinary natural phenomena as the occurrence of great commercial crises, have been submitted by Professor Jevons to statistical investigation, and brought, possibly, within reach of the helping hand of science.

> "For so the whole round earth is every way
> Bound by gold chains about the feet of God."

It seems reasonable to lay much stress on the unequivocal way in which such calamities as famine make for righteousness; stimulating generosity; attaching a practical value to the results of the highest kinds of scientific research; or dealing a straightforward knock-down blow to a corrupt policy. Is it wrong for a whole population to depend on a single article of food, calling for little exertion or intelligence in its cultivation? Famine strikes at the root of the evil. Is reckless waste of valuable natural productions a vice? Mr. Wallace, in his work on *Tropical Nature*, 1878, bears witness to the irreparable devastation and consequent scarcity of food caused by the reckless clearing of forests in some parts of Brazil. In short, the disciplinary character of famine is so evident that we must regard it as forming a part of that great economy of Nature by which men, through the necessity of procuring an abundance of various kinds of food, have been stimulated to agriculture and commerce, to science and the arts, to thrift and enterprise, and to relations of intimacy with other peoples far and near, conducing eminently to the general good.

3. *Storms.* At first sight there may appear to be something like a paradox in representing liability to the perils of storm and tempest as beneficial to seafaring men. Nevertheless it may be shown to be in some respects quite true. Ships have to be built, and in every way fitted out, and crews have to be engaged, so as to be able to meet the emergencies occasioned by stress of weather. Hence, whilst moderate weather prevails, the ship is stronger and the crew more numerous than the necessity of the case requires. If it were possible to offer to our seamen a security that the wind should never rise above a capful, or a steady breeze, or even half a gale, they would reject the offer with contempt; and they would be right.

Within the last half century, not only sailors, but multi-

tudes of emigrants, and regiments of soldiers, and crowds of civilians of all ranks, have had to undertake ocean voyages. At any given time the population afloat is so considerable that few of us, in behalf of relations or friends, can fail frequently to "think upon the dangers of the seas." Yet these perils are distinctly beginning to develop the characteristic feature of remediability through knowledge. Even on the high seas, a thousand miles from land, a knowledge of the law of storms has done much towards enabling the mariner to avoid, or escape from, the terrible cyclone. And though the science of storm-warnings is in its earliest stage, yet the surface of the globe has already been mapped out in large areas, each of which has its own centre or origin of atmospheric disturbances and its ordinary course of storms. Such a centre lies too near our own western coasts to admit of the accurate fulfilment of all the storm-predictions received from America; the storms from the West being frequently affected by meteoric disturbances originating in our own neighbourhood. These difficulties are, however, only the inevitable imperfections of a new science.

Few coincidences can be more remarkable than that by which the recognition of the storm-course was attended by the discovery of a messenger—by means of the electric telegraph—able to outspeed the tempest on its own path, and to give timely warning of its approach. May not the desolating hurricane of the future confer on man the privilege of putting a girdle of helpful kindness round the earth, each nation warning a sister nation of the coming peril?

4. *Earthquakes*. Sufferers by earthquakes may perhaps be classed with other victims who have wittingly incurred special risks, such as miners, divers, and aeronauts; for it very rarely happens that a destructive earthquake affects a population unwarned by the previous occurrence of calamities of a like character. Professor Huxley regards earthquakes as

reparative agents, tending commonly to the more or less permanent elevation of portions of the solid crust of the earth; thus counteracting the slow but constant action of subaërial denudation.

If we take the published records of the pestilences, famines, storms, and earthquakes which have occurred during the present century, we shall find ourselves possessed of volumes of horrors, from the study of which we might rise with the impression that the world we live in must be a veritable Tartarus. Yet it is easy to see that the sum total of the misery may bear an infinitesimally small proportion to the whole life history of the century, *if it could be written.* Herein lies the source of a deep misapprehension of Nature. Few great catastrophes go unrecorded; but the uneventful hours, days, years, and lives of the 900,000,000 of our race cannot be recorded; they afford no materials for history or even for news. The true inference is, that ours is a world in which happiness is so much a matter of course that writers take no notice of it; in fact, society is no more sensible of happiness than our bodies in health are sensible of the processes of respiration or digestion.

We have now to consider a class of facts differing from those already mentioned in being of a more permanent kind. Strictly speaking, a hurricane or an earthquake is not an interruption of the orderly course of Nature; yet, because it is an event circumscribed in time and place, it can be dealt with as having a character of its own. But when we attempt to consider the moral significance of such a feature in Nature as the existence and condition of the human race, we become conscious that the field of enquiry is too vast to be explored, or even surveyed, from any single station point.

Moreover, certain considerations intimately affecting the question must be foregone for want of space. The natural

history of moral evil might occupy a lengthy treatise. Yet it seems only a busy trifling to speak of Nature's kind provision for birds and flowers if we decline to face the enquiry—What has Nature been towards man, civilised and uncivilised, in the past as well as in the present?

The first and most obvious reflection is that Nature is manifestly in a state of transition, and may justly claim the consideration which is always accorded to unfinished productions. We reasonably pass a modified opinion on a work of art in its rough state, but hardly venture to condemn it, for we know not yet what the artist will succeed in doing with certain portions which may strike us as unseemly. It is true that the history of mankind, for some thousands of years past, presents a mournful prevalence of hurtful activities; and that by asserting a constant progress in amelioration we deepen the gloom that hangs over the past. The time seems long; but Nature, in her greater operations, is lavish of time, and draws freely on her inexhaustible resources. Why should Nature be in a hurry, as if any one was likely to take the business out of her hands? In this our time-difficulty we have the critical help of Geology. We hear of palæozoic æons, but have not yet assimilated the fact that human existence, from first to last, on the most ample geological computation, might fitly serve as a single unit in reckoning the age of the earth. If it had been possible for us to have observed the countless annual cycles of our planet during the Laurentian or Silurian periods, we might impatiently and ignorantly have said—the promised age of intelligent creatures will *never* arrive.

If the difficulty of all difficulties be man in his worst estate, the crowning achievement in Nature is man in his highest and best estate. The loftiest pyramid *must* have the broadest base. And if it be said that this implies the sacrifice of the many for the exaltation of the few, it may be

replied that the gospel of uniformity is no gospel at all, but a delusion; and that the lower ranges of mankind are not sacrificed, but sheltered and greatly benefited, by those above them.

Distressing as it may be, the condition of our street Arabs must not be estimated by what their lot would be to our own children if they were reduced to it. Says Mr. Mill, more forcibly than elegantly, dirt is not uncomfortable except to those who are not accustomed to it. Even pain itself is not always misery; few wish to escape it by death, even when there is no dread of what may come after. There is a wondrous order of compensation in Nature. If the suffering be great, sensibility often slumbers; and the deepest mental anguish yields to the healing influence of time. Well, replies the pessimist, but that *must* be the case from the very nature of things. Yes, that is what I say--the healing is *natural.*

It is a fact worthy to be regarded with profound attention that through all the ages of the human kind, and in every land visited by the light of day, the only way of escape from wretchedness is by progress in that which is on all hands admitted to be good. Humanity in its wild, untutored condition is exposed to passions ferocious and unconstrained; yet if there be bright spots in the life of a savage they are lighted up by qualities which all men everywhere agree in calling good. There are swarms of moral outcasts at our very doors: latent virtue developed in themselves by active virtue seeking out the lost, is the only remedy. "Be not overcome of evil, but overcome evil with good," is a precept as wide as the emergency it implies.

An opponent may reply that this is to argue in a circle, and that it is the helpfulness of virtue that makes it virtue. But to this I demur. It is not the usefulness of truth that makes truth to be true. Why should not deeper wickedness be needed to stamp out wickedness, and itself be brought to

an end by something viler still ? Such questions, strange as they may seem, touch the very root of the matter when we are enquiring—Is Nature cruel ?

Immoral enticements. Before leaving the part of our enquiry which turns on the question—Is Nature cruel to man ? —it is necessary to approach a difficulty which can at most be very imperfectly either stated or solved. If Nature be credited with kind relations in attaching pain and inconvenience to vice, it might seem that relations of an opposite kind ought to be inferred from the prevalence of allurements to evil. Why should some actions and habits, confessedly injurious to man, be attended by such gratification as renders them too often fatally attractive ? For example, the immoderate use of narcotics or stimulants.

It may be observed that actions and habits necessarily self-injurious are not attractive to any living thing except man. That he has this pre-eminence cannot be denied ; but it would be a harsh inference that the distinction is wholly on the bad side. It must denote in the human race a speciality of some higher kind, with which the extra trial is associated. Whatever it may be, it is something more than any ordeal through which the most intelligent brutes have to pass.

Corollary. Such a habit as that of drunkenness cannot have been attained through natural selection and the survival of the fittest, that is, of the most advanced, drunkards.

The speciality of the difficulty suggests an explanation. If deterrent pain were always concomitant with every wrong action, in no conceivable way could our present state of existence have any high educational value. That under certain conditions some wrong things should be pleasant, is indispensable, if scope is to be given for choice on higher grounds than those of immediate gratification. On a miserably cold wet morning I am tempted to sit by the fire reading or

writing. But some case of sickness or want, two or three miles away, requires my service, and I conquer my inclination and go out. Under the circumstances, to sit still would be to inflict a moral injury on myself; yet to remain by the fire would be very comfortable; and I cannot say that Nature is to blame for making the hurtful thing pleasant.

It is said that man in a state of nature is brutish; that he ill-uses his wife, and makes her carry his burdens and do all the hard work, whilst he fights or sleeps in the sun. Very true; but the wife would turn the tables if she were strong enough. So long as there is no more powerful might than strength of arm, the weakest must go to the wall. This may not be the best kind of social or domestic policy; but there are tyrannies more galling and intolerable than the masterful rule of the strong arm. Simultaneously with the development of the inner man, stronger forces come into play; intellect and the higher emotions are in action, and they prevail. But there is no contending against Nature in the case, as is often asserted. This feeling of antagonism towards Nature is about as wise as the anger of a spoilt boy against the author of his summing-book for making the sums hard. Man's intelligence and kindness are as much his natural endowments as are his muscular energies. The will of the civilised man is on the side of befriending the weak, as the will of the savage is on the side of oppression. Man in his best estate has a contest, not with Nature as his enemy, but with his own lower propensities, good and necessary in themselves as his servants, but all unfit to be the ruling principles of his conduct and character. The lower propensities and the higher endowments are from the same source.

Creatures noxious to man. We have already considered a case included in this category of such momentous import that all others are by comparison of little account. I refer

to the living poison-germs in zymotic diseases. The authority of Florence Nightingale may be quoted for the assertion that it is wrong for parents to regard whooping-cough, measles, and scarlatina as ills to be expected in the ordinary course of nature, and as rather to be welcomed than otherwise, for the sake of having them well over. Pestilence, in one form or other, is perhaps the greatest of human calamities; and if we have rightly estimated its character, we may pass over a whole crowd of minor troublers causing annoyances which cannot seriously affect our question.

Intestinal worms. *Tænia* and *Trichina* make a great figure in the reports of fault-finders who dilate on the agonies inflicted on human beings by these wretched entozoa. But the life-history of the tape-worm and its allies renders it clear that the true horrors belong, not to the pain they inflict, but to the social abominations which render the existence of these pests possible. To me it seems at least probable that the ancestors of the tape-worm were perfectly respectable, and that its place in nature has been attained, not in the regular ascending order, but through many degrees of degeneration and degradation, co-ordinated with debased habits in man.

Some travellers in tropical regions represent the prevalence of insect pests as rendering life a burden. Perhaps the sufferings endured in such localities from bites and stings are not more than a reasonable price to be paid for the enjoyment of Nature in her equatorial glory. Besides, we must not be misled by the prevalence of such complaints. Any scribbler can relate how scorpions and centipedes take shelter in boots, and huge cockroaches are served up in the soup, and ubiquitous ants suffer their bodies to be torn from their heads sooner than release their grip on the human skin. Writers, such as Wallace and Bates and Belt, without ignoring the annoyances, speak of them in a less querulous and

more manly way; having better topics wherewith to fill their charming and instructive pages.

Mosquitoes are amongst the delinquents most frequently put forward as capable of serving no good purpose, whilst inflicting intolerable pain. Nevertheless, it is quite possible that the lives of many travellers are saved every year by these tiny tormentors, whose kind offices, in driving the tired wayfarer from the deadly marsh, to find rest and sleep in a higher and healthier locality, are not always appreciated. And this is not all that may be said for these irritating little plagues. I have myself seen mosquitoes, and their allies, hovering over a notoriously unhealthy swamp in the neighbourhood of a town, in such countless numbers that I could only compare them with a bank of fog. It is, I think, probable that the aërial life of a mosquito is limited to twenty-four hours. Each winged mosquito in the cloud had been a larva in the swamp below. These larvæ are active and very voracious; and their life from the egg to the perfect insect may last fully ten days.* Therefore, in order to supply the daily or nightly cloud of the insects, more than ten times as many larvæ must constantly be feeding in the moisture of the swamp. What is their food? It must be organic, immensely plentiful, and exceedingly minute. It must be something very like those microscopic poison-germs which ascend into the air with the water as it passes into a state of vapour, and which are the sources of the deadly fevers associated with malaria. Of the millions of these poison-germs possibly destroyed by the larvæ of mosquitoes, no computation can be offered. In the case above alluded to, it is quite within the range of probability that the habitableness of the town might be, as mathematicians say, a function of the execrated mosquito cloud.

However this may be, it is quite unnecessary, in order to

* "Three or four weeks."—*Westwood*, vol. ii., p. 512.

vindicate the beneficence of Nature, that we should be able to shew that all living things, noxious and innocuous, are useful to man.

Beasts of prey and venomous snakes are chargeable with destructive propensities which every year occasion the loss of several thousands of human lives, nor am I aware of any directly extenuating circumstances, or beneficial services, which might be alleged in their behalf. Indirectly, every object of knowledge must be of some service to man. Nature, however, wholly discountenances the idea that man is the sole object of the creation. He fills the most exalted place in the visible world. His position is *sui generis;* and so far as the intelligent appreciation of the order and meaning of Nature is concerned, without man there might as well be no life at all on the earth. Man is at the head of all, but he is not the solitary final cause of all.

Some may regard this conclusion as of too remote a character to be of much real importance. To myself it seems rather to be the substance underlying all moral inferences reasonably to be derived from Nature. Man, assumed to be the end and object of all, *must* look on the facts of Nature as either loyal or treasonable towards himself. His interests may not be in common with those of his surroundings. Circumstances, kind towards them, may appear unjust towards him; or, cruel towards them, may appear kind to him. It is only by recognising his place in Nature as a part of a great united whole that man can regard the teachings of Nature as trustworthy.

Man may not require that some of his race should annually be torn in pieces by tigers, or perish from the bites of rattle-snakes, without these creatures having to make any recompense to him, in order to teach him that they owe him no fealty. But it is possible to conceive of a state of things so invariably favourable to man as to suggest the flattering

notion that his interests alone are consulted in natural arrangements. And, in point of fact, so generally kind and useful is Nature towards him, that he not unfrequently makes this mistake, loses his temper, and abuses Nature without measure, whenever facts do not run smoothly with his pretensions.

In passing on to enquire whether any indications of cruelty in Nature are to be found amongst creatures inferior to man, it is proper for me to acknowledge the extreme value of Mr. Darwin's theory as forming a connecting link between an almost innumerable array of facts, which would otherwise have to be considered, each on its own merits, a task well nigh impossible. Whether the theory of "natural selection," or "the battle of life," be sufficient to account for all the phenomena of the animal and vegetable kingdoms, or not, it affords the only ascertained basis of operation available for our purpose.

The battle of life. The first impression made upon my own mind by the perusal and reperusal of Mr. Darwin's work on the origin of species, soon after it was first published, was very painful. It was indeed almost like listening to the knell of the departed joys of Nature. Flowers seem to flaunt their colours in pride of victory; and the very songs of the birds were truculent. A great discovery had no doubt been made; but many minds at the time felt, and there are those who continue to feel, that something had been taken from the aspect of Nature, the loss of which it was impossible not to deplore.

The question for the present day may be — Is there compensation? I think so. That which has been lost may be compared with our delight when, as children, the coppice with its bluebells and the honeysuckle in the lane were to us as true joys and blossoms of Paradise. That which has been gained is an intellectual gratification of the highest kind, but

withal very grave. Under the new light Nature keeps no holidays. Birds and flowers are working for their lives when they warble or look pretty; and the light-hearted merry laugh finds no response "in the goode green woode when mavis and merle are singing." Under the absolute control of "natural selection," Nature is not cruel or mournful or melancholy, but only extremely business-like. Perhaps this may be the true aspect of life. I think not. There is an alternative. Perhaps, in recognising the battle of life, we see only one side of a great truth; and it may happen that with more perfect vision the gaiety of Nature may reappear.

That the battle of life does not increase the whole amount of suffering in the case of animals, seems to be sufficiently plain. The death of the victim that becomes the prey of some stronger or more subtle animal is attended by less pain than if the creature had lived to be destroyed by the infirmities of old age. Of what may be termed the natural death of wild animals very little is known; for the most part they disappear. But in the case of man's faithful companions, the dog and the horse, it is often felt to be an act of mercy, when extreme old age approaches, to accelerate death by some expeditious method. A trying thing it is to give the necessary order for the fatal shot that is to end the sufferings of an attached companion, brute only in name, that for years may have had no joy but in his master's service, nor any reward like that of his master's notice and word of praise. It is still more trying for the master to do the deed himself, lest the hand of an indifferent executioner should prolong even for a moment the passing struggle. Yet so clear is the merciful character of the act that it has often been thus done. Man, at no little cost to himself, out of love and mercy, does just what Nature does by the battle of life, only in the latter case, not the weakness of old age alone, but every infirmity and inferiority is taken into account.

In the millions of living things, quadrupeds, birds, fishes, insects, that are devoured every day, the painful end is very short, and is limited to a duration which bears no comparison with the days or years of the previous enjoyment of life. For, notwithstanding their constant liability to the attacks of enemies, the tenants of the land and of the water, with few exceptions, pass their lives in unsuspecting enjoyment. Instead of sending forth her children to spend their lives ever harassed by painful apprehensions, Nature weaves for them a protective mantle of mimicry; and weak things wear their fears, in manifold broidery of plumage and hair and scale, upon their backs instead of in their hearts.

No one can reasonably doubt that much beauty of form and colour in animals has been developed through the exigencies of self-preservation. Captain Harris, who was almost the first to explore the wide plains in the interior of Africa, populated by vast herds of ruminant animals, together with fierce carnivora, describes the intense admiration with which he beheld for the first time some of the antelope tribe previously unknown to science. A biologist would tell us that the clear liquid eye of the springbok, in imitation of which the Egyptian lady stains the roots of her eyelashes with kohl, expresses an extreme need of watchfulness; that the conspicuously variegated skin of the animal enables it, even in the confusion of hasty flight, to recognise at a distance other individuals of its own kind and herd; that its outline is clear and fine as that of a racehorse, because a single ungainly pound of flesh must bring certain destruction upon the laggard animal when the crafty foe springs from his ambush upon the affrighted herd. The springbok *is* a beautiful creature; but the leopard and the lion have done their share in rendering it so. Perhaps natural beauty in any creature is seldom more willingly admired than when an angler, after a keenly contested struggle, fairly succeeds in

laying his fresh-run salmon of twenty pounds beside him on the green turf. Yet its lines owe something of their fineness to the destructive propensities of the otter. I see no cruelty here; it is better that inferior forms should have been killed off.

It has been alleged that Nature disposes all her arrangements for the benefit of the species, but cares not for the individual; does, in fact, unsparingly sacrifice the individual for the good of the species. There must be some misapprehension here. A species has no existence except as an aggregate of individuals; and the good of the species must mean the good of its constituents. Inferior forms in any species or race, so long as they exist, have all the advantages of which they are capable; and it is no hardship to them that their successors may be superior to themselves. Except in cases of degeneration, every animal or plant enjoys its position through the operation of long ages of development; suppose it destined to be supplanted—to the extent of its capacity as an individual—it has been befriended by Nature.

Self-sacrifice in Nature. For the sake of replying to a friendly criticism on this point, I may ask permission to quote a short passage from *Notes by a Field Naturalist in the Western Tropics*, referring to a wild forest road in the island of Dominica:—

"The scene may be regarded as a battle-field of life; the strong crushing the weak, with no exemption from the common lot allowed even for the noblest or most beautiful of forms. Such an interpretation of Nature would be superficial and unworthy. Life and death thus intermingled are, in fact, a most impressive illustration of the greatest of all truths—that in Nature nothing lives or exists for its own sake alone. The noble tree strangled and at length borne down by the noxious parasite, and the delicate fern or moss eaten by the canker-worm, have no untimely, no ignoble end. In their witness to a law involving partial evil, but securing universal good, in no very remote sense they are martyrs, and fulfil a destiny higher even than the exhibition of their own perfect and unsoiled beauty."

My friend suggests that the idea of self-sacrifice is not founded on natural facts; but that, on the contrary, all things do their very best to avoid being victimised.

In reply, I would ask—If the conception of voluntary self-sacrifice be not from Nature, from what other source has it been derived?

It is clear that development through natural selection could not have been worked out on the principle of self-sacrifice; moreover, it is equally clear that the thing itself, self-sacrifice, *could not exist in the absence of an intellect capable of entertaining and appreciating the idea.* If the antelope yielded itself an easy prey to the lion, our reading of Nature must remain unchanged, inasmuch as we could not regard the self-sacrifice as made with consciousness. What takes place amongst the lower animals, inevitably by the rule of the stronger, we, beholding the good results, may reasonably construe according to our higher capacities; not transposing the order of Nature, but using our reason as the astronomer uses the diurnal eye-piece of his telescope, to see things, not inverted, but as they really are.

Why then complain that the gaiety of Nature has suffered? Because, for the present, we have to a serious extent lost our sense of individuality and spontaneity in Nature. The secret of a joyful contemplation of Nature is sympathy. When a flower expands or a bird preens its feathers in the sunshine, we attribute a certain sense of freedom and happiness to the life thus manifested, and in this gladness we ourselves share.

Most of us have seen one or more of those marvellous constructions of mechanical ingenuity, generally enclosed, like pictures, in gilded and glazed frames, representing animated scenes in Nature. The sails of the windmill revolve; the railway train passes over the viaduct; a butter-

fly flits from flower to flower; the chimes of the church tower play a merry tune; the cascade pours its crystal stream into the pool; a little bird flutters as it sings; a swallow wheels its flight across the valley. We see it all, and our curiosity is aroused and gratified; but not one spark of genuine gladness of heart is elicited. The mechanism is wonderful and the combinations most surprising; that is all. We return and bring a friend to see it. The same song of the bird is accompanied by the same little flutter of the wing; the same butterfly visits the same flowers; the swallow skims across the glen in precisely the same way; and the water in the pool is neither higher nor lower than it was before. Now this is what we do *not* find in Nature because of life. But if life be a mere running down of energy stored by a certain process of winding up, then Nature is the clock-work scene over again, on a larger scale, more complicated, more varied, more wonderful, but not more joyful.

But we are threatened with a loss of a much more serious kind than that of forfeiting our enjoyment of Nature. Mankind are invited to regard life as without a Divine Source, without a personal will, without a living spirit, and without a future. And the grounds on which a proposition so startling has been made, are assumed to be purely those of natural science. Hence the popular misconception that socialism, nihilism, and determinism are in some way favoured by the teaching of science. Even in parliament this error is not without influence; and the interests of higher education suffer from it far and wide.

Now, if it were possible to take a panoramic view of all the magnificent achievements of science during the last half-century, we should, I think, be profoundly impressed with the number, vastness, and solidity of those additions to our knowledge which are compatible with, and even ancillary to, a religious faith, as compared with the speculative character

of the inferences which form the sum of all that can be adduced on the opposite side.

If these inferences, for example, the mechanical hypothesis of life and volition, be sound, Nature is false to convictions which, of all, do most persist in consciousness; and which, therefore, according to Mr. Herbert Spencer, must be true. But to be false is to be cruel.

Nature is neither cruel nor kind, say some, but entirely indifferent. She just goes on her own way unmoved by groans or cries. Her way may be a good way for general progress, but she is utterly careless at what expense of suffering she secures improvement. Now, *that* which may justly be accredited with indifference, is the course of a natural law. But Nature is neither a law, nor a bundle of known laws. Nature is not indifferent, but sensitive, exquisitely sensitive; only the way for us to move Nature is not by groans and cries and ashes thrown on the head, but by availing ourselves, through knowledge, of her exhaustless store of resources.

Great inconsistency has arisen from the assumed extension of the action of known laws into regions in which their mode of working is unthinkable. The anticipated discovery of Neptune affords no parallel whatever with the speculative assumption that thought and consciousness are modes or products of molecular activity. That they are concomitants, no one denies. Does any one *know* more than this?

Elsewhere I have attempted to shew that the natural history of scientific hypotheses relating to life exhibits pretty uniformly a succession of stages. First, the conjectural state; then, the confirmatory stage; then, that in which the theory assumes the form of a demonstrated law or combination of facts; next, the speculative stage, in which the absolute universality of the law is by some asserted; and, lastly, corresponding with the highest and most perfect state of knowledge, the stage in which certain limitations and

exceptions are admitted; such limitations being due to the presence of unknown laws, which do not necessarily detract from the value of the theory as a working hypothesis. For example, the theory of genera in animals and plants, as defined by Linnæus; Schleiden and Schwann's cell-theory; Harvey's theory, *omne vivum ab ovo;* the theory of reproduction by sexual fertilisation; Darwin's theory of natural selection, through the survival of the fittest. Others might be added; but these have not been selected because they are convenient, but because I know not any greater or more valuable theories in biological science. Yet they fail, not because of the imperfection of our knowledge, but because we already know too much to admit of any one of them being accepted as a scientific dogma.

Of course, Nature can be in accordance with only one of the stages to which we have adverted, and that the last. If, therefore, the theory of evolution, with its associated hypotheses, be, and many considerations tend to shew that they at present are, in the penultimate stage, Nature may still appear gay in her attire, and her whole aspect, without exception, may be regarded as favouring the claims which most of the wisest and best thinkers of all ages and nations agree in assigning to man.

I am not pleading for a piece of teleology where all is teleological, lateral issues in countless ramifications being equally final causes with those which apparently lie right ahead; so that of no single fact in Nature is it possible to say that it exists independently of any other given fact. But I may reasonably press the conclusion that to recognise a final cause, not in one favoured creature or class, but in everything animate or inanimate that exists, is to approach as nearly as possible to the conception of perfect beneficence in Nature.

ON MODERN METEOROLOGY, CONSIDERED IN ITS BEARING UPON TROPICAL STORMS.

By ARTHUR E. NEVINS, Associate.

Some thirty or forty years ago, the interest of the scientific world was very much aroused by a theory which was brought forward to account for those terrible tropical storms known in different regions in which they occur by the several names of typhoons, cyclones, and hurricanes. This theory was called the "circular theory," and in addition to describing the various phenomena which had been observed in connection with these storms, its propounders, among whom may be mentioned Reid, Redfield, and Piddington, laid down certain rules for the guidance of navigators in managing their ships when involved in these storms.

The basis of the circular theory on which these directions were founded was, that these storms moved bodily along in certain directions which had to be ascertained by experience, and that the atmosphere in the storm moved round in concentric circles, the force of the wind becoming more and more intense as the centre was approached, and that the direction of the revolutions was contrary to the hands of a watch in northern hemisphere storms, and with the hands of a watch in the southern hemisphere storms, or, in other words, that the winds on the side of any circular storm nearest the equator were westerly. It will be seen that if these facts were correct, the relative position of any ship and the centre of the storm (that is, the region of greatest danger)

could always be ascertained from a knowledge of the direction of the wind found at the position of the ship. The centre of the storm would always bear at right angles to the direction of the wind, and hence the rule was laid down that if you face the wind in a circular storm in the northern hemisphere, your right hand will point to the direction of the centre, and in a southern hemisphere storm your left hand will point in the direction of the centre.

More recent experience has shown that while the circular theory is in the main correct, it is faulty in its details, and in certain cases misleading.

The points which I wish to bring before your notice this evening are:—That tropical storms are more circular on one side than on the other, and that in certain parts of the storm there is good reason to believe that the wind blows dead into the centre of the storm, instead of in a circular direction round it.

Also, that the researches of modern meteorologists have shown that it is necessary to adopt a much more extensive method of observation than was used by Reid, Redfield, and Piddington in investigating storms, in order to arrive at a correct idea of their configuration. And also, that our recently extended knowledge of ocean meteorology has disclosed some important facts regarding the normal winds prevailing over the areas in which these storms appear to originate.

There is one great fact which formed part of the circular theory, and which, as it has been found to be correct, may be disposed of at once, and that fact is, that while the atmosphere in the storm moves round over a certain area in a more or less circular direction, the whole body of the storm progresses in a direction which is so far constant in the various regions in which these storms occur that it may be ascertained by experience.

It may be said, as a rule, that the storms of both hemispheres, after their formation, first progress westward, nearly parallel to the equator in low latitudes, and that they afterwards gradually turn toward the pole of whichever hemisphere they may be in, and expend themselves in the higher latitudes, in some cases recurring a little to the eastward.

It has been already mentioned that in many of its details the circular theory is faulty, and there are many reasons why it should be so, for at the time when Reid and others were making their investigations, the number of ships from which observations could be obtained was much fewer than at the present time; and also the captains and officers of these ships were, many of them, men of slight education, and with very little scientific knowledge. One fact may be mentioned to illustrate this. In Reid's book, some of the captains whose observations he quotes, refer to the reading of their barometers not in inches, and tenths, &c., but that the glass fell to "stormy," and again rose to "change," or to "fair." Again, the instruments in use at that time were frequently of very inferior construction, and, in many cases, ships went to sea without barometers on board. There was no system established for taking and recording observations, and the information had to be culled from any log books which could be obtained, and these were frequently very indifferently kept. In looking through the extracts from logs given by Reid in his book, there is frequent evidence of want of accurate details in the logs themselves. In many instances no records are given in the logs of the distance made from hour to hour, nor even of the courses steered.

It may be said that, in the majority of cases, the circular nature of any particular storm at any particular time had to be determined by observations from not more than three or four ships, and these observations were taken only approxi-

mately, that is, within say half-a-day, in many cases, of the same time.

At the present time the two principal authorities on circular storms are Mr. Meldrum, the Astronomer of the Mauritius Observatory, and Captain Toynbee, the Superintendent of the Marine Department at the Meteorological Office.

In investigating the phenomena connected with circular storms they have both adopted the method of making a series of synchronous charts of the area affected by the particular storm which they may be discussing.

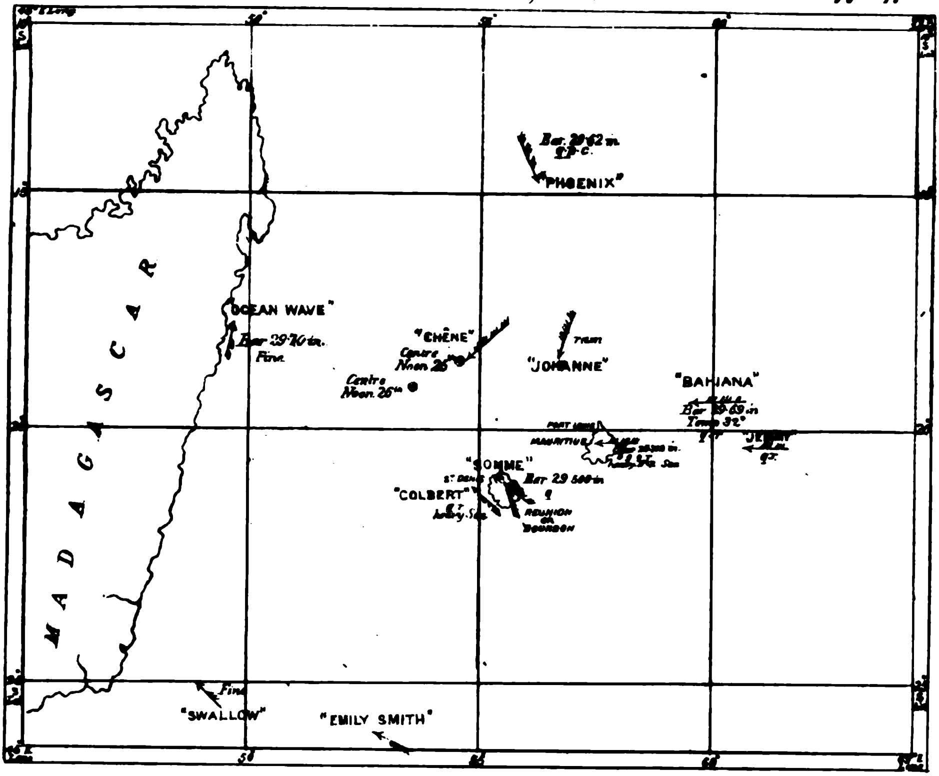
The method which Mr. Meldrum adopts in constructing synchronous charts is the following:—When a storm has passed over the Indian Ocean, as many of the logs of ships which have been anywhere in the region of the storm's track as can be obtained are collected at Mauritius. They can often get a good many there, because the greater part of the vessels which suffer injury in Indian Ocean hurricanes put into Mauritius to refit.

A chart is then prepared, and a certain date fixed upon, as, for example (in the case of the accompanying chart):—Noon at Mauritius, on Feb. 25th, 1860.* (Plate 1.) The position of every ship at that time, whose log is available, is marked on the chart, and the direction and force of the wind, and state of the weather, as recorded in her log for that time, is marked beside her position, and also the height of her barometer and thermometer. In this manner a graphic description is obtained of the direction and force of the surface wind, at a certain moment of time, over the whole area affected by the storm, and also generally in some regions beyond the area of disturbance.

By making a series of such synchronous charts for noon on succeeding days, the gradual size, and onward progress of

* See *Notes on Forms of Cyclones of Southern Indian Ocean*, by C. Meldrum, M.A., F.R.A.S., Meteorological Office—Non-official, No. 7.

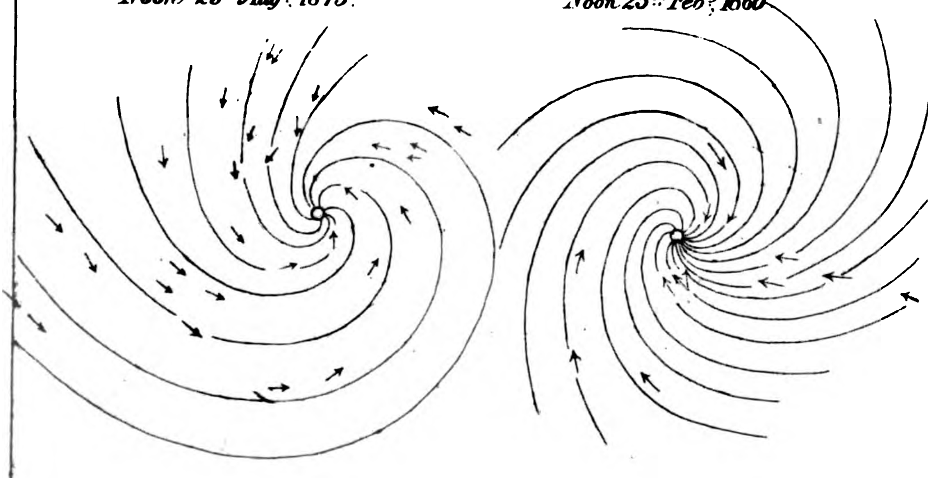
Noon 25th Feby 1860. № 1.



CYCLONES.

DIAGRAM 3.
Noon, 25th Augt 1873.

DIAGRAM 4.
Noon 25th Feby 1860



a storm can be traced, and its configuration at various periods of its existence can be ascertained.

In August, 1873, a most destructive storm swept across the southern part of the North Atlantic, and up the eastern coast of America, and a few days after it had passed up the American coast a terrible storm was experienced on the eastern side of the Atlantic. The method adopted by Captain Toynbee in investigating the movements of the atmosphere in these storms, was to obtain thirty-one charts of the whole of the North Atlantic Ocean, including the eastern coast of America, and the western coasts of Europe. One of these charts was devoted to each day of the month of August. All the logs which could be obtained of ships which were in the North Atlantic during the month were collected, and all the observations recorded at the American and European observatories throughout the month were also obtained.

The position of all the observatories was marked on these charts, and the positions, at a certain time on each day, of all the ships from which logs had been obtained were also marked. The time fixed upon for each day was 0h 43m p.m. at Greenwich, because that time corresponds with 7h 35m a.m. Washington time, and that is one of the times when observations are taken every day at all the United States observatories. Beside the position of every observatory and ship, was marked the direction and force of the wind, and also all the recorded readings of instruments, and the general state of the weather. By this means a meteorological diagram of the whole of the North Atlantic at a certain moment of time, on every day of the month, was obtained; and from these diagrams the gradual formation of the hurricane could be seen, its progress from day to day, its final and gradual dying out, and the return to its normal condition of the atmosphere after the passage of the storm.

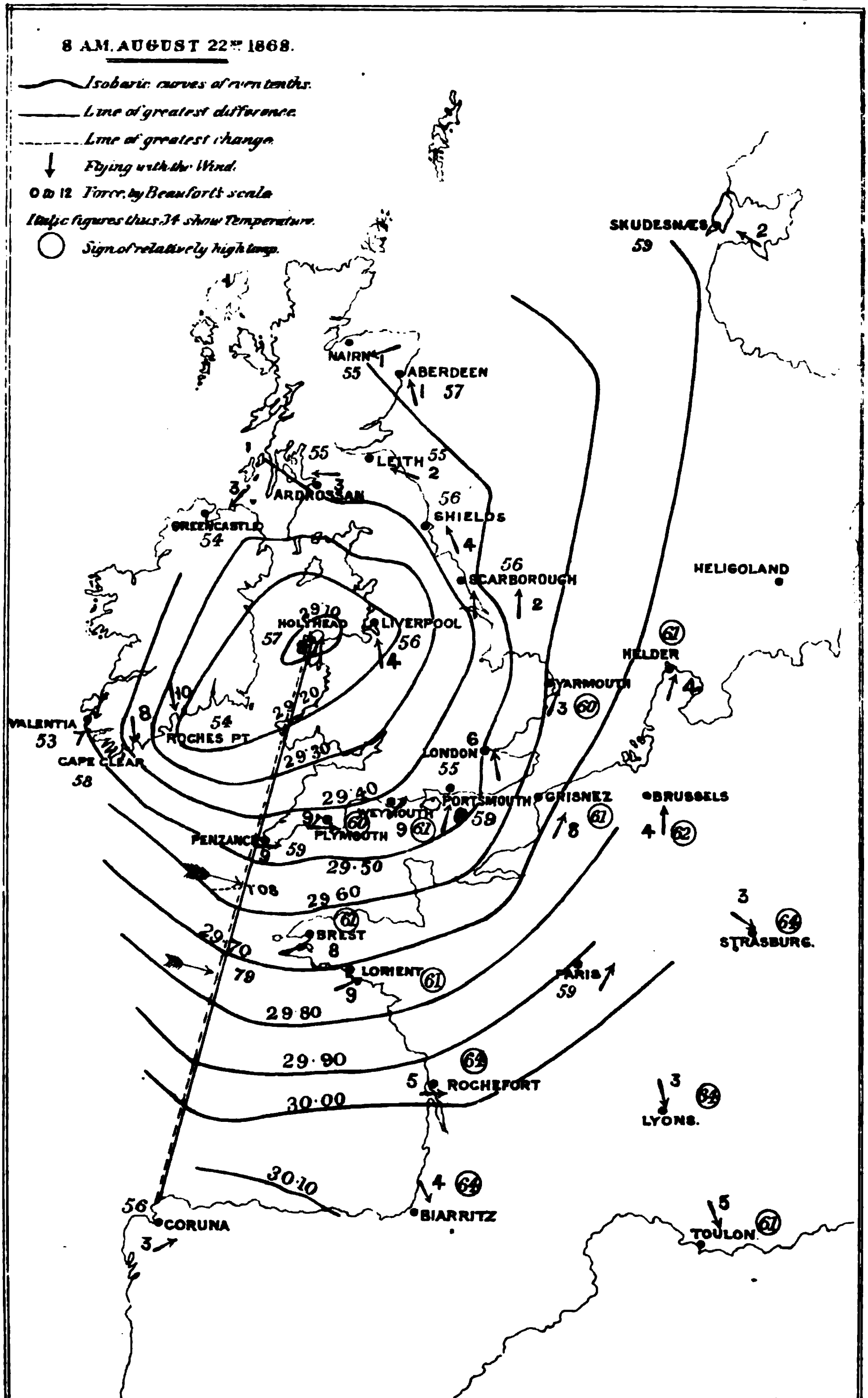
This method of making synchronous weather charts is used not only for the investigation of great and abnormal atmospheric disturbances, but it is also used in the every-day work of the Meteorological Office. Observations of all the meteorological instruments, and also of the state of the weather, are made at all the observatories of the British Islands and western coasts of Europe, at 8 a.m., Greenwich time, every day, and the results immediately wired to the Meteorological Office, in London, and from these observations a chart is made, showing the isobaric and isothermal lines—that is, the lines along which the barometric pressures are equal, and those along which the temperature is equal—and also the state of the sky and sea all over the western portion of Europe at the moment of 8 a.m., Greenwich time. It is by the aid of these charts, principally, that the weather forecasts are made at the Meteorological Office, and storm-warnings sent round the coasts. They are published by many newspapers on the following day, and anybody who takes in the *Liverpool Mercury* may see them printed there every morning. It was also by the aid of synchronous charts that one of the most important laws of the relation of barometric pressure to the direction of the wind was established; it is known as "Buys Ballot's law," from the name of Professor Buys Ballot, who discovered it.

This law is, that if in the northern hemisphere you stand with your back to the wind, or in the southern hemisphere with your face to the wind, your right hand will point to a region of higher barometric pressures, and your left hand to a region of lower barometric pressures.

The accompanying chart* (Plate 2), for 8 a.m., August 22nd, 1868, shows this very well. It is taken from a chart published by the Meteorological Office. It will be seen from this chart that the lowest pressure lay over Holyhead, and

* See Paper on use of Isobaric Curves, by Capt. H. Toynbee, F.R.A.S., &c.

No 2.



8 AM. AUGUST 22nd 1868.
Isobaric curves of even tenths.
Line of greatest difference.
Line of greatest change.
Flying with the Wind.
0 to 12 Force, by Beaufort's scale
Italic figures thus 34 show Temperature.
Sign of relatively high temp.
SKUDESNÆS
NAIRN
ABERDEEN
LEITH
ARDROSSAN
GREENCASTLE
SHIELDS
SCARBOROUGH
HELIGOLAND
HOLYHEAD
LIVERPOOL
HELDER
YARMOUTH
VALENTIA
ROCHES PT
CAPE CLEAR
LONDON
PORTSMOUTH
GRISNEZ
BRUSSELS
WEYMOUTH
PLYMOUTH
PENZANCE
STRASBURG.
BREST
LORIENT
PARIS
ROCHEFORT
LYONS.
CORUNA
BIARRITZ
TOULON.
29·10
29·20
29·30
29·40
29·50
29·60
29·70
29·80
29·90
30·00
30·10

that the isobaric lines lie, in a more or less circular direction, round the central depression. It will also be seen by the arrows that the direction of the wind was almost parallel to the isobaric lines, and that if, in any part of the area, an observer stood with his back to the wind, his left hand would point to lower barometric pressures, and his right hand to higher pressures, than that found at his own position. It is found that the more settled and steady the weather is, the further apart the isobaric lines are, and the nearer the isobars are together, the more unsettled and stormy the weather is. The same law seems to hold good for the whole system of the atmospheric circulation, for in the trade wind regions the isobaric lines lie in the direction of the prevailing wind, and, therefore, if an observer stands either with his face or his back to the wind (according to the hemisphere he is in), his right and left hands will point across the isobars, and therefore, of course, to regions of higher and lower pressures.

Those who have read up the circular theory will remember the explanation which was offered by its propounders of the diminution of pressure in the centre of the storms. They said that if water, or any fluid, were placed in a circular vessel, and caused to rotate rapidly inside the vessel, the centre would become depressed, and below the outside parts which are elevated above the normal level; and they suggested that in a circular storm the column of air might similarly be shorter, and, therefore, lighter in the centre than at the edges of the storm, and that, therefore, the barometer would be lower in the centre than at the edges. Any such explanation is unnecessary if Buys Ballot's law is correct, because in circular storms the relation of barometric pressure to the direction of the wind is only the same as in all other movements of the atmosphere.

Having now seen the method adopted at the present time

in investigating atmospherical disturbances, before we pass on to the results of modern research in regard to tropical storms, it may be well to take a glance at the meteorology of the parts of the ocean in which these storms originate, in order to understand the normal directions, and other peculiarities, of the currents of air which produce these fearful storms.

[A description was here given with a chart of the general circulation of the atmosphere over the tropical portions of the oceans of the world, showing the positions of south-east and north-east trades, monsoons, &c.]

The most important fact which it is necessary to notice is, that in every region in which these storms originate, the prevailing winds at different seasons of the year blow from *directly* opposite points of the compass, and also that the prevailing current at one time of the year is much more moist than that which prevails during the other part of the year.

The regions in which these tropical storms originate in the northern hemisphere, are the China Sea, the Bay of Bengal, the low latitudes of the North Atlantic, where the West India hurricanes originate, and the low latitudes of the North Pacific; and in the southern hemisphere, in the low latitudes of the Indian Ocean, where the Mauritius hurricanes are formed.

The prevailing winds in the China Sea and Bay of Bengal are, during the summer, the south-west monsoons, which are heavily charged with moisture; during the winter months, a north-east monsoon blows over the same region, and it is a dry wind, especially in the Bay of Bengal. In the low latitudes of the North Atlantic and North Pacific, the north-east trade is the prevailing wind during some months of the year; but during other months in the same latitudes, and on the West Coast of Africa, and the Isthmus of Panama,

there is a south-west monsoon,* and it is much more moist than the north-east trades.

In the low southern latitudes of the Indian Ocean, the south-east trade blows during some months of the year, and over the same area during other months there is a north-west monsoon, and it is more moist than the south-east trade.

If two currents of air meet end-on, if I may use such an expression, one of two things must happen—either one must pass over the top of the other, or else each must be diverted from its course, and pass round the side of the other. It seems, from the observations of Mr. Meldrum (of Mauritius) and others,† that in the hurricanes of the Indian Ocean the south-east trade sweeps round the southern side of the storm, and the north-west monsoon round the northern side, in two, more or less, distinct curves, and that between them there is an easterly current of air blowing almost directly in towards the vortex. The accompanying chart, showing the state of the weather at noon on February 25th, 1860 (Mauritius time, chart No. 1), over an area of 800 miles by 700 miles, in the neighbourhood of Mauritius and Bourbon, is copied from one given by Mr. Meldrum. It gives a synchronous set of observations from the observatories of Mauritius and Bourbon, and from the logs of ten ships scattered over the area. The arrows near the position of the various vessels, show the direction of the wind they were experiencing, and the numbers indicate its force by Beaufort's scale (0 being calm,

* The amount of moisture which has been observed in the different winds referred to above has not been published, but Capt. Toynbee has been kind enough to give me, in a letter, the following figures:—In the southern part of the north-east of the North Atlantic the difference between the wet and dry bulb thermometers was 5° F, while in the south-west monsoon the difference was only 2°·6 F.

† See *Notes on the Forms of Cyclones in the Indian Ocean*, by C. Meldrum, M.A., F.R.A.S., published by the Meteorological Committee of the Royal Society—Non-official, No. 7.

and 12 hurricane force). From this chart it will be seen that, in this instance at any rate, the wind did not blow in concentric circles, and also that any attempt to ascertain the bearing of the centre, according to the circular theories, from the direction of the wind, would have been misleading in nearly every instance. The wind at Mauritius, and at the ships "Bahiana" and "Jemmy," was east, and, therefore, the centre should have been north of each of these positions, whereas it bore about north-west, or even more westerly than that, its position at that time being close to the ship "Chéne." Again, the ship "Colbert," having the wind from south-east, ought, according to the circular theory, to have had the centre to the north-eastward of her, and therefore she might have run to the north-westward with moderate safety; instead of that, a north-west course, as a matter of fact, would have carried her almost direct towards the centre of the storm. Mr. Meldrum's paper was published in 1873, and he had then had twenty years' experience in investigating these storms, and the diagram (Plate 1, No. 4) is a copy of the one which he gives to illustrate, as nearly as possible, the usual shape of a fully-formed southern hemisphere cyclone.

In giving his conclusions briefly, it may be said that the whole body of these storms seems to progress in a west-south-westerly direction during the greater part of their existence, and at an average rate of about six or seven miles an hour; they afterwards become nearly stationary, and then commence to go southwards, and recurve to the eastwards toward the end of their career. With regard to the management of ships in them, he says that all ships which have the wind anywhere between north and south through the western half of the compass are in comparative safety, and that they should endeavour to hold to the northward; with regard to the easterly winds, it seems a doubtful matter what course should be pursued; every man must be guided by circum-

stances, but the wisest course, as a rule, seems to be to hold to the eastward against the wind as much as possible.

It has been already mentioned that Captain Toynbee has published a very careful examination of the winds and weather of the North Atlantic Ocean during the month of August, 1873. In this work * he has shown by charts the progress of the storm along its track from day to day, and also the direction of the winds observed in various parts of the area covered by the storm at a certain time (0h 43m p.m., Greenwich) on each day. Plate 1, No. 3, shows the general shape of the storm, obtained from these observations, on August 25th, 1873. This particular date has been selected as giving a good example of the form generally obtained. It appears from Captain Toynbee's investigations, that in this storm the south-east and east winds were those which blew more in towards the centre than any others, in the same way that the north-east and east winds of the Mauritius storms blow towards the centre. He also points out that the winds all round the storm incurve towards the centre, and that they seemed to do so to a greater degree near the centre than in the outer parts of the storm. This is another important point of difference between the circular theory and the more recent researches; for the propounders of the circular theory believed that the storms were more nearly circular near the centre than away from it.

According to the circular theory, a line from the ship's position to the centre of the storm ought to lie at right angles to the direction of the wind, but from a table given by Capt. Toynbee, showing the result of one hundred and eight observations taken on board ships whose position with regard

* "On the Great Hurricane, the Tracks of American Storms, and the Ordinary Winds of the North Atlantic experienced in August, 1873;" a paper read before the Royal United Service Institution, June, 1877; also *Nautical Magazine*, Dec., 1877.

to the centre was accurately known, it seems that the average value of the angle between the direction of the wind and the bearing of the centre is 118°; that is to say, the average incurvature is 28°, or 2½ points.

If this is correct, it follows that in whatever part of a storm a ship is, she will be approaching the centre in a more or less oblique direction if she runs dead before the wind. It may, therefore, be taken as a desirable modification of the circular theory, that in cases where the circular theory would advise a ship to run, she ought to keep the wind well on her starboard quarter, if she is in the northern hemisphere, and well on her port quarter, if in the southern hemisphere, instead of going dead before it.

In the course of my own experience at sea, I have only once had the misfortune of being involved in one of these tropical storms, but in that one case, the winds that we experienced did not agree with the circular theory.

This cyclone came upon us in the Bay of Bengal, in about the latitude of Madras. It came on first with the wind at north-north-west, gradually increasing from a light to a strong breeze, and with severe squalls from north-east.

We stood on for about fourteen hours, close hauled, making what little distance we did make in a southerly direction, and though the wind during the first five hours had increased to a strong gale, after that the weather did not get much worse. During these fourteen hours the barometer only fell about the tenth of an inch. The ship was then put before the wind, and ran to the south-south-eastward for about eight hours. As soon as ever we began to run, the weather got worse, and the glass fell much more rapidly, the amount being three-tenths in these eight hours. The sea was by this time running in a fearful way, very high, and from every direction; it was more like the commotion in a

boiling cauldron than anything else. The ship was then hove-to on the starboard tack, and for the next six hours things continued much as they were, except that the wind, which had remained pretty steady from north-north-west for about twenty hours (except in the squalls), began to haul to the westward. The glass fell a little, about 0·05 inches, for the first three hours after we hove-to, and then was steady for about three hours. After we had been in the storm for about twenty-eight hours from its commencement, the barometer began to rise, and the weather to moderate, the wind hauling to the southward, and afterwards south-eastward.

Now, if the winds in this storm had blown in concentric circles, with the wind at N.N.W., we should have been in the south-western quadrant of the storm, and therefore to southward of the storm's centre, and as the storms in this part of the world travel along in a direction between west and north-west, we could not by any possibility have got near the centre, in a sailing-ship, with the wind northward. But the sea we experienced, and the state of the weather generally, left very little doubt that we did get pretty close to the centre, at any rate, quite close enough to expose the ship to very serious danger. Again, by running to the southward and south-eastward, with the storm working to the northward of west, and the ship being to the southward of the centre, we certainly ought to have got more moderate weather; but, on the contrary, as soon as ever the ship was put before the wind the weather got worse, the barometer fell, and the sea increased and became more confused—in fact, there was every sign that we were approaching instead of getting away from the centre. If, however, this storm had been of a shape somewhat similar to that given by Captain Toynbee for the northern hemisphere (see Fig. 8), the phenomena which we experienced would be easily accounted for, as it

will be seen that N.N.W. winds are found to the northward of the centre, and that there are north-easterly winds not far from them, which might account for the heavy north-east squalls which we experienced while the general direction of the wind was N.N.W.

The intense violence and long continuance of the north-westerly winds which we experienced in this storm led me to notice, in reading Reid's book, that in almost every instance where he gives observations taken in hurricanes *while in low latitudes*, that is, between 20° N. and the equator, the most intense violence of the wind was experienced between west and north-west. Almost the only wind observation given on Captain Toynbee's August charts in low latitudes also gives an almost hurricane force from north-west.

Putting all these things together, it is a question, which may perhaps be solved by further observations, whether, in northern hemisphere storms, while they are in low latitudes, the greatest incurvature, and the most intense force of wind, may not be found to come with the winds between north-west and west.

It will be seen, from what has been already said, that although, in some of its details, the circular theory may be incorrect, our best thanks are due to those who originally propounded it; because they, as it were, struck the key-note of the explanation of these storms, and pioneered the road for others who have followed them. The great authorities on meteorology of the present day are unanimous in saying that more facts are required before any really certain knowledge of the laws which govern great atmospheric disturbances can be arrived at.

Among other questions of great interest which still remain to be solved, perhaps the greatest is, Whence is the enormous force obtained which is displayed in these storms,

when they are formed by the collision of two currents of air of only very moderate strength?

All who have given accounts of the phenomena which accompany these storms have particularly alluded to the enormous rainfall which accompanies them, and also to the very vivid displays of electricity which are seen in them. In the storm which I myself saw, both these phenomena were witnessed in a manner not to be easily forgotten. Throughout the duration of the violence of the storm the water came down in sheets, almost too heavy to be called rain, and although the thermometer stood above 80° Fahr., the rain was so cold, and came down with such force, that it cut one to the skin through a serge jacket and flannel shirt. When such a tremendous fall of rain takes place, there is of course an enormous amount of latent heat set free, and this may perhaps be one of the producing causes of the great violence of the wind.

With regard to the electricity, when this storm was coming down upon us from the eastward, we saw the grandest sight that can be imagined. For almost a couple of hours before the storm overtook us, the whole sky, from about north-east to south-east, and to an altitude of about 30° to 40° above the horizon, was one continual blaze of electric light, and across this sheet of light forked lightning and balls of fire were continually shooting.

From the fact that such displays of lightning, not always, perhaps, so intense as in this case, accompany these storms, the question arises, Is it likely that the two currents of air forming the storm are charged with electricity of opposite names? and, if they are, would the fact of their being so charged add to the intensity of the force of the wind forming the storm?

These questions, with many others, still remain to be answered by future investigations.

ON THE COLOURS OF THE SEA.

By J. LINTON-PALMER, R.N., F.S.A., F.R.G.S.

I PROPOSE to read a few notes on this subject for three reasons:—

1st. Because I have been asked here, what was the reason of the name of a certain sea.

2nd. Because I do not think there is any nation which is fonder of the sea and all connected with it than we are, and so hope that my remarks will not be devoid of interest.

3rd. Because I have seen many, or even most, of the facts I relate.

And by sea I mean the ocean, which is so alive with currents that at no part is it stagnant, as inland seas may be.

I begin with the conventional colour of the sea, which to most people seems of a greenish tint.

I find no mention of *colour* either in Assyrian or Hebrew records.

The earliest remarks are by the Greeks.

In Homer, purple (πορφύριος), pretty commonly; cloudy-looking (Ηεροειδης); in the Odyssey specially violet-coloured (Ιοειδης); wine-coloured (Οινοψ); blackening (Μελας); grey (πολιος); pale blue (Γλαυκός); swallow-coloured (Κυανεος) is used by Euripides and Simonides, but not by Homer. These last three often by the tragic poets. Æschylus uses red-bottomed (φοινικοπεδος), and (ερύθρος) blushing-red, but only of the Red Sea.

The Latin poets are very silent as to the colour of the sea. Virgil alone uses as a term (albescere) the whitening of the surface during a squall.

Ossian, than whom few are more abundant in description of the appearance of nature, talks of a blue, dark-blue water.*

In the Norse and Icelandic sagas we find "Rān's couch of deepest blue," "the azure garments of Œgir's daughters," etc.

Among modern and our own poets, I need but say *the blue* is the predominant idea, and, lastly, our seamen speak of "blue water" when they are out of soundings, although in the same place they will tell you they have "shipped a green sea."

Some seas have acquired specific names, as the White, Black, Yellow, and Red Seas, and the Gulf of California is called "Vermejo," or Vermilion Sea, by the Spaniards.

Apparent Colour

is due to optical effects; in fine weather the sea seems blue by the reflection of the sky-colour from its surface. This is varied by cloud-shadow, and again the reflection from the bottom may alter the tint, and this, more or less, by its distance from the surface.

As to why the sky is blue, Sir J. Herschel and J. Tyndall consent it is *one* of the enigmas. The observations of the latter, and his experiments to prove whether it may not be due to molecular polarization are well known.

True Colour.

But when we gaze into water, pure and deep, it gives us the idea it is blue, and in this respect it differs from the air; the sky, from a deep valley, or when the air is damp, is much fainter in tint than when it is seen from a height, in fact, as many here know, the higher we go, the darker

* Carthon *et passim.*

does the sky seem; at very great heights it seems to blacken, as the air becomes rarer; with water the reverse occurs.

River and lake water has usually a green tint; even the mighty Niagara is grass green; the exception being in that which is of ice origin. The Lake of Geneva, we all know, is very blue, as is also the Rhone, where it leaves it*—and I could give other examples.

Blue is the salt sea colour, but this differs in various parts of the world. In equatorial seas the water is dark blue, in extra tropical seas dark green.

The Mediterranean is deep blue, the Red Sea deeper; I think it is deepest at the Straits of Jubal. The Gulf Stream is indigo blue. Many here know how blue and defined it is; a ship may have her bow in the blue and her stern in the green water. It has been suggested to find the longitude, approximately, by this phenomenon. The Indian Ocean is blue-black, and so is the Japan Current, the Kara Siwo, or "the Black River."

Can this be due to the effect produced by the relative quantity of salts these waters contain?

The salterns of France and Italy are a series of ponds into which the sea-water is admitted, and as evaporation progresses and its density increases, so does the colour of the brine vary. In the ponds next the sea the water is green. This changes until, in those farthest off, where crystallization is ready to commence, the water is deep blue, and where it commences a reddish tint is evident. So constant is this appearance that it guides the salt workers in their operations. †

As a rule, the constituents of the ocean are pretty constant

* I have been told this is due to the impalpable dust of mica suspended in it.

† In the south of Hampshire I have noticed this red tint at the edges, but found there great quantities of *Artemia Salina* and *Chirocephalus*.

in quantity, its specific gravity varying from 1·022 to 1·027, or even more.

Koldeway found at the North it was	...	1·024–25
Schweitzer,	Mediterranean	1·025
Giraud,	Babelmandeb	1·023
	Straits of Jubal	1·027
Rodgers,	(correcting to 28° F.) Gulf Stream	1·030
"	Arctic Ocean, similarly corrected	1·026

Many times I have found the water 83° F., and we are assured it is sometimes 95° F. And as sea-water of the same density is 1·029 at 28° F., 1·026 at 64° F., and 1·022 at 93° F., it is a pity that these different specimens were not corrected for temperature.

Inland seas, as the Baltic and Black Seas, are not so salt, from the preponderance of river supply over evaporation.

Maury says:—"The densest sea-water is off Cape Horn, *but* it was not corrected for temperature."

Let us say that in the Bay of Biscay there are 3·5 per cent. of salines, 4· in the Gulf Stream, and 4·5 in the Indian Ocean.

One cogent reason for thinking that the blue colour of the sea depends on its salineness, is the fact that copper-sheathed vessels (men-of-war), cruising about the West Indies (*e.g.*), from whence the Gulf Stream is fed, suffer more from erosion than in many other places.

No one, I believe, has tried to find out whether the blue colour may be due to polarization caused by the molecules of salt in the water.

I said that certain seas had been so named from the colour of their water, which is, perhaps, not always, but sometimes, so tinted; and I will try to give you the cause of this occurrence in some of them.

The White Sea.

I have never been there, but infer only that it originally derived its name from the pale grey-green of the water which is common in its vicinity. But white sea is by no means uncommon in the South Pacific. I find in my notes, "The sea, off Paita, whitish, or pale pea-green, ... due to vast quantities of minute entomostraca." A very trustworthy observer here, tells me he has again and again sailed in white sea, which he ascribed to *spawn*, *i. e.*, minute organisms.

Captain Newbold* noticed that, when near Bombay, the sea was milky-white, owing to the presence of innumerable animalcules, some of which were large enough to be visible to unaided sight.

Yellow Sea.

The Yellow Sea, *par excellence*, of China is not the only sea which is yellow. Along the coast patches of this yellow water is met with frequently. In some places there is a scum such as one sees on a stagnant pool, which, in calm weather, is thrown up in a thick cream-coloured pellicle. This is not so marked, of course, in a gale.

One observer† places its limits at the Formosa Straits, in 25° north latitude, and the Rhio Straits at the equator; but it is of greater extent.

The same yellow sea was noticed by Captain Cook, who tells us that it is found all about the east coast of Australia, and round New Guinea. His sailors called the cause of it, sea-sawdust, and its presence gave an oily look to the water.

I have seen and examined it often, and believe it to be, as represented, an alga, *Trichodesmium*, but not always

* Philosophical Transactions, 1772.

† Dr. Collingwood.

sheaf-shaped, sometimes fusiform, and never having a reddish tint. In the sea near the Galapagos Islands, there have been seen, by Captain Colnett and Darwin, stripes of dark yellow water, a few yards only in width, but miles long, the colour caused by little gelatinous balls, say one-fifth of an inch in diameter, in which numerous minute spheroids, of two kinds, are embedded. Darwin says he has no notion what they are. Dr. Wallich says, in the Bay of Bengal he has found yellow water, due either to the *Trichodesmium*, in spherical balls one-twentieth of an inch in diameter, or as bound sheaves or faggots, one-twelfth to one-twentieth of an inch long, or to masses of diatoms. One form, *Rhizosolenia*, in dishevelled tufts like floss-silk, one-half to one-and-a-half inches long. Salpæ and hydrozoa feed on this till *they* impart a tint to the water. Another form, *Coscinodiscus Regius*, one-twentieth of an inch across, is found in countless myriads during calms, and so bright that single frustules were observable at some distance.

Green Sea.

I am not aware of any sea being so named, but sea-water in many places is very green.

This is generally caused by reflection of light from a coral or white sand bottom, and is principally found in the Lagoon Islands, as Keeling Atoll, the Paumotoo group, and such like. The effect of the contrast between the outer blue and the inner green water is much impaired if the atoll is covered with tall trees. One of the most charming is Ducie's Island, which looks like a chaplet thrown on the ocean. It is encircled by a broad fringe of snow-white breakers, and the inside water is vivid emerald.

Nor is it necessary that the lagoon should be shallow; with a depth of even 366 feet the contrast of colour is strongly marked.

The water of the Dead Sea is delicate green. As this lake is surrounded by white cliffs and white sand, the colour is probably due to the same cause, although the water is very salt, containing 26 per cent. of salines.*

Also, in the deep ocean, near Keeling Atoll, Darwin has noted the colour changed by the presence of some *conferva*, the cells varying from ·08 to ·04 inches in size, the colouring matter contained in a colourless envelope. Sometimes this was brown, not green. No doubt these were dead specimens.

Chamisso tells us of the Bandes Vertes he saw, between Teneriffe and Brazil.

Scoresby says that in the Arctic seas are stripes and patches of green water.

Nordenskiöld, that near Spitzbergen the water is grey-green, due to the enormous quantity of diatoms.

Black Sea.

There is nothing remarkable in the colour of the Black† Sea or Euxine. In the Pacific the water has changed to black, and exhaled a sulphurous stench after a volcanic eruption. I remember, after such an event, the water fizzed like soda water, but its colour was unchanged.

Red Sea.

We now come to red sea, and the first to be noticed is the Red Sea, the water of which is very deep blue, the intensity of its colour depending, in the opinion of many, on the great amount of salt it contains. This must occur, because, as you see, it is in a rainless district—no river empties itself into it. The air is very hot, aiding evaporation; the temperature of its water varies from 80° to 95° Fahr.; it is a

* Porter.

† Name due to its blackening under squalls, very common there.

huge saltpan, so to say, whose level is kept up by influx of water through the Straits of Babelmandeb. In many places the shore is incrusted with salt.

It has always had the name blush-red (ερυθραιον), not bright-red (πύρρόν); and, as I said, Œschylus calls it red bottomed (φοινικόπεδος). In Arabic its name is Bahr-es-Souph, Mare Algosum. Pliny speaks of it as a submarine forest, Mare Rubrum . . . . refertum est sylvis (of Algæ). Diodorus says its colour is scarlet or bright-red. In our times, Captain Newbold, a very accurate observer, found the bottom coloured with annular, crescentic, or irregular purplish-red blotches, due to patches of red standstone and red coral, and which curiously contrasted with the ultramarine of the water over the white coral reefs. Dean Stanley speaks of the abundance of these forests of submarine vegetation, and of the dark coral reefs of this fantastic sea.

But there is another reason for its name. Ehrenberg and others have found large tracts of its surface covered with strata of a very minute alga, a *Trichodesmium*, one variety of which has a very strong smell, and this principally in the winter months. Some observers say this is coloured brick-red or blood-red. Dr. Collingwood, who passed through the sea in March, was not so fortunate as to find it; no more was I at a little later time; but it seems that the sea may have been so named, first and generally, from the colour of its bottom, and not from its occasional surface tint.

But besides the so-named Red Sea, I said the sea was coloured red occasionally. This redness is either of an opaque or transparent nature.

One of the best examples of the *opaque* is noticed by Darwin, who, when near Tierra del Fuego, found narrow bands of red water, abounding in Entomostraca, genus *Cæto-chilus*. The sealers call it "whale's food," the seamen "spawn."

Another red sea-water also noticed by Darwin, I have seen several times. The "Beagle" passed through a quantity of this ruddy water, some fifty miles from land, between Concepçion and Valparaiso.

"The water, under the microscope, was seen to swarm with minute objects, darting widely about. They were oval in form, and round their middle was a ring of vibratile cilia.

"As to careful or precise examination, that was almost impossible, inasmuch as the instant motion ceased, the cells or bodies burst either at one or both ends, and were dissipated into a cloud.

"About two minutes after the isolation of any quantity of these bodies this event occurred.

"Their numbers were infinite, and one space passed through was several square miles in area.

"The colour of the sea was that of a river which has passed through red clay land (when seen from some distance); by the vessel's side it was nearly chocolate-brown. The line of separation between this and the other sea was clearly defined, and the sea near these patches abounded unusually with living creatures."

In the spring of 1851, when off the west coast of South America, I noticed the same colour, and found it due to the same or a similar cause, and I found the same difficulty of precise examination that he complains of. The cell was in rapid motion and rotation; all at once it disappeared, was dissipated into a cloud of spores. In vain I tried to preserve this form for future examination; in every re-agent I had it was not persistent. I do not remember ever having had so worrying a thing to examine.

I am inclined to put it down to the genus *Trachelomonas;* but may it not be possible that this curious ciliated spheroid may be a sporangium, of diatomous origin (some catenoid form?), ready to reproduce, but showing itself as a

separate existence for a brief time only? I should be glad to know if any other observer has met with it.

Among those who have commented on the next cause of red seas are Lesson, Péron, Labardillière, and Flinders.

I have seen it often, but the last time I specially examined it was in the spring of 1868, in lat. 13° S., long. 78° W. The water was brown-green. As we neared Callao, 3rd April, I find noted, "Water, till last night, rust-brown, now rust-black, with a thick scum on the surface; soon after it assumed a dull green, and afterwards, for some days, the water was stained as if with clouds of blood or gore from a slaughter-house. The total distance of this discolouration was about seven hundred miles."

It was due to diatomaceous growth, the cause being *Prorocentrum*, of a non-luminous variety; and this was evident, whether the water was of one tint or the other.

I was able to preserve this form, which I now exhibit. At the time, I sent a few words and some specimens of it to the *Microscopic Journal*, in London, in which paper you will find it.

Dr. Collingwood found, in the Formosa Channel, bright red water, caused by the presence of myriads of gelatinous worms.

As regards the alga *Trichodesmium*, which tinges the Red and Yellow Seas, I have never had an opportunity of examining the former, which has been described by Ehrenberg, Montagne, Hinds, Darwin, and Dr. Collingwood. Ehrenberg found it in the Red Sea; Hinds, off St. Salvador and west coast of North America; Darwin, near the Abrothos Shoals; and Collingwood, in the Red Sea and Indian Ocean. This red variety is like a sheaf. The yellow variety, which I know well, that found in the China seas and in the south, is more wedge-shaped, and from one-twentieth to one-tenth of an inch in length, quite opaque, looking very like oscil-

toria. You will find a long account of it in the *Quarterly Microscopic Journal*, April, 1868. Dr. Collingwood says he found with them occasionally minute spheres, about the size of a pin's head, solid and opaque, bristling, like an echinus, with minute rays.

Another red sea has been reported; it happened early in this year, in the track of the fishing-smacks which ply between Florida and the Havannah. It was in strata of dark red water, and so eminently poisonous, that the smacks found it almost impossible to bring their cargoes in their wells alive into port. Captain Allan, in the "G. Storrs," tried to evade it by running to the west, but when fifty miles west of the Tortugas, all the fish died rapidly. Large fish, such as sharks and jew-fish, also turtle, were found dead about the vessel at this point, one hundred and fifty miles from Cape Florida, not far from Middle Gulf. It was supposed to be of inland water origin, but no authentic detail of it is given.*

Brown Sea

is found near Greenland.

Arctic Seas.

The peculiar colour of these seas has always excited the attention and remarks of the voyagers in them, from the earliest times, not only by its variation, but by the rapidity with which the changes succeed. The first man who tells us about it is old John Davis, who, in 1585, when commanding the "Sunshine and Moonshine," found, in the Straits which bear his name, that "the water was very blacke and thicke, like untoe a filthy standing poole." Henry Hudson, in 1607, notices the changes, but erroneously attributes them to the presence or absence of ice, a mere accidental coincidence.

* "He turned their water into blood, and slew their fish."—Psalm cv., 29.

The sailor-savant Scoresby, 1817, tells us more at length of what he saw. That discoloured water forms about one-quarter of the sea between 74° to 80° north latitude, and is often in bands or streams of very variable dimensions, which lie more or less north and south. In that year, at the parallel of 74° N., from 12° to 0° E. (200 miles), the water was blue and transparent, then grass-green and opaque, sometimes progressively, sometimes so suddenly that the line of separation was like the rippling of a current, the two waters keeping quite distinct from each other.

In 68° N. and 12° W., he found brown water; rather higher up grass-green, with a shade of black.

Dr. R. Brown, who has frequently visited these seas, found the Greenland seas vary from ultramarine to olive, from transparency to dark opacity, and these changes were persistent, not transitory phenomena. In a few hours he has passed through patches of deep black, green, and sky-blue, the water, too, being sometimes so opaque that tongues of ice and other objects could not be seen at the depth of a few feet. Nordenskiöld says that in these seas a ship may sail with the one side in blue, the other in grey-green water. At Spitzbergen there are two usual colours, indigo-blue and grey-green; in the Greenland seas, brown also. Koldeway corroborates this.

The colour of "the black waters" has been ascribed to the presence of organisms on which the right-whale feeds. Scoresby thought the medusoid the chief form; Brown found associated with this the crustacean (various entomostraca, as *Cœtochilus*, &c.), and molluscs (as in the pteropod form, *Clio Borealis*). The whalemen rejoice to find this dark water, which is so full of these organisms sometimes (he notices one evening in particular), that a few minutes sufficed to catch a pint measureful of them and other forms in the net. This was when the temperature was 32′ 5″ Fahr.

Next morning, position and other circumstances being the same, but the temperature of the sea at 27′ 5″ Fahr., no ice at hand, in half-an-hour not one specimen was caught.

But though they had disappeared, the sea kept the same tint, and in the water abundant forms of diatoms were found. The alimentary canals of the "whale's food" were found full of them also.

The most prominent form of diatom is a melosira (*M. Arctica*). It looks like a delicate beaded necklace, in diameter about $\frac{1}{750}$ of an inch, in length of "*beads*" $\frac{1}{550}$ or $\frac{1}{500}$ of an inch. The colour of the *beads* (cells) dark brown-green; the *necklace* might grow to the length of one-tenth of an inch. These diatoms grow and accumulate under the floe-ice to such an extent, that when it breaks up in early spring the brown slimy bands thus formed on the surface of the water have been mistaken for *Laminaria*, a kelp-weed; also, deep down, say two hundred fathoms, very few of these organisms have been found.

So it would appear that these colours are due not so much to animal as to vegetable life, as we have seen to be the case in other parts of the ocean.

As biological facts, few are stranger than the diatom which stains the broad frozen sea, affording pasture to myriads of forms which are the sole sustenance of

> "Leviathan,
> Hugest of living creatures, on the deep
> Stretched like a promontory;"

and thus completing the wonderful cycle of life.

For a full account of the various diatoms which stain this sea-water, I refer you to the *Arctic Manual* of the Royal Society, p. 319.

There are also some other streaks of discoloured water in the Arctic, but merely local and accidental, known to whalers

by various and not euphonious names. These, also, are wholly due to diatoms.

Antarctic.

On my first passage round Cape Horn, I every day, gale or no gale (and we had our full share of them), examined the sea-water, which I never found *blue*, but it swarmed with various forms of diatoms. Unfortunately, my sketches and note-book of these things have gone some years ago, so I cannot show you their likenesses. I have not been further than 64° S.

Milky-Way Sea.

It was on New Year's Day, 1851, in 39° S., 55° W., I passed, in the ship of the late Admiral of the Fleet, Sir F. Moresby, through a milky-way in the sea.

It was a breezy evening, the wind from the N.W., and enough to let the ship go about nine or ten miles an hour, when, as evening fell, we noticed that the sea glimmered, and this increased as the sky darkened, till it seemed as if we were in a cream sea. I went on the bowsprit, and put my towing net overboard, and finding that in a few minutes I had enough material caught to enable me to judge of the cause, I had leisure to examine the weird effect produced by this sea. I went farther out on the bowsprit, and saw that the ship was rushing through living white water, the ripple from the bows being rather more vivid than the rest; and when a break took place on the top of the swell, the same effect occurred. The sky was as dark as pitch, hardly a star to be seen. The Southern Cross, which so many have raved about, was dimmed to insignificance. The whole of the rigging, sails, and spars of the ship stood out against the gloom like a phantom ship; it gave me the idea of the sea being the sky and the sky the sea—very

beautiful but very ghastly. I do not know how long this continued.

On examining the water, I found the appearance to be owing to Peridinia; *Tripos* seemed to predominate. Of course there were other forms of diatom, but few other organisms, so few as not to vitiate the conclusion that Peridinium was the "lamplighter."

Specimens and drawings, which I took at the time, were sent to the Admiralty, and to Dr. Acland, at Oxford.

I saw this appearance, near the same parallel, once again, but whether as a second appearance, or whether not so bright as on the first occasion, it had not the same spell on my imagination. An observer saw nearly the same off the west coast of Sumatra; his description of it is given in "Maury," p. 284, but it does not seem due to the same cause.

Major S. Owen, in his account of the surface fauna of the ocean, notices that, having fallen in with shoals of entomostraca, the contents of his towing net seemed like liquid fire when emptied on the deck. This was in the Bay of Bengal, but he does not say the general look of the sea was such as I have tried to describe.

The Sea under Aurora.

I will not trespass further on your time than by adverting to another accidental colour of the sea—that caused by Aurora. One account is given by Maury; of it I give a short extract. It was in a mid-winter gale off Cape Horn, a heavy sea running; the heavens pitch dark, not a star to be seen. The murkiness began to change, till the sky seemed living fire, casting a glow on the ship. The sea, too, seemed vermilion, as the waves dashed in crimson torrents over the ship; sails, spars and all put on the same hue, as if in a terrible conflagration.

"Taken altogether," says the narrator, "the howling of

the wind, the furious squalls of hail driving over and falling to leeward in ruddy showers, the mad plunging of the ship into the crimson sea, and the awful sublimity of the heavens, across which the auroral light darted in spiral streaks with meteoric brilliancy, caused a scene surpassing the wildest fancy—words fail to give a just idea of the spectacle."

I have, more than once, seen the sea under Aurora, but not in so awe-inspiring a manner; yet the effects of the light, both on sea and ship, were equally evident and weird.

THE SOLUTION OF THE PROBLEM OF THE AUTOPOLAR P-EDRA, WITH FULL CONSTRUCTIONS UP TO $P = 10$.

By THOMAS P. KIRKMAN, M.A., F.R.S.

1. In an autopolar p-edron, to every edge $ABcd$, whose faces are an A-gon and a B-gon, and whose summits are a c-ace and a d-ace, corresponds one edge $CDab$, whose faces and summits are reciprocals of the former, A and a, like B and b, etc., being the same number. These edges are a pair of reciprocals.

2. Every *nodal autopolar* has two, and only two, *nodal faces*, Θ and Δ, each containing its reciprocal summit, viz., θ and δ, which are the two *nodal summits*. An *enodal autopolar* has no nodal face or summit.

3. The *nodal angle* of Θ is $\gamma\ \theta\ \lambda$, and that of Δ is $\pi\ \delta\ \phi$. The summits γ and λ are the *nodal tips*, or the *tips* of Θ, and π and ϕ are the *tips* of Δ.

4. The edges $\theta\gamma$ and $\theta\lambda$ are the two *nodal sides*, or the *sides* of Θ, and $\delta\pi$ and $\delta\phi$ are the *sides* of Δ.

5. Of the faces collateral with Θ, Λ which contains the side $\theta\gamma$, and Γ which contains $\theta\lambda$, are the two *nodal walls*, or the *walls*, of the node Θ. Each wall, Γ, is the reciprocal of the opposite tip γ, and each side is the reciprocal of the other side. In like manner the *walls* of the node Δ are Π, containing ϕ, and Φ containing π.

6. If the summits of the face Θ are in order $\theta\gamma\mu\ .\ .\ .\ \lambda$, the faces about the summit θ are in order $\Theta\Lambda\ .\ .\ .\ \mathrm{M}\Gamma$, reciprocals of those summits.

7. If the faces collateral with Θ are in order $\Lambda\mathrm{AB}\ .\ .\ \mathrm{F}\Gamma$, the summits in the rays of the pencil θ are in order $\gamma f\ .\ .\ .\ ba\lambda$, reciprocals of those faces.

The faces A and F next to the walls Λ and Γ are the two *by-walls* of the node Θ, and their [illegible] the [illegible]

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Here Θ has two triace tips, and consequently two trian-

11. *Reduction of a t-node.* Every t-node Θ of a p-edron H has at least one side $\Theta\Lambda = \theta\gamma$ (4) which can be deleted, while its reciprocal $\theta\lambda = \Theta\Gamma$ convanesces by the coalition of θ and λ. The two faces Θ and Λ revolve into one, which is the new nodal face Θ', containing the new nodal summit θ', made by the union of θ and λ. H has thus become an autopolar $(p-1)$-edron H'.

If the t-node Θ in H has two reducible tips, $\theta\lambda$ instead of $\theta\gamma$ can be deleted, while $\theta\gamma$ convanishes, and we have another $(p-1)$-edron H'', different from H', if $\theta\gamma$ and $\theta\lambda$ in H are not identical by reason of a zonal trace between them.

The new nodal face in H' is a $(\Theta+\Lambda-3)$-gon; that in H'' is a $(\Theta+\Gamma-3)$-gon. The p-edron H will be built by our processes both on H' and on H'', and H is said to be twice made at its node θ. If H, being asymmetric, can be thus also twice reduced at its node δ, it is said to be four times made. No H can be more than four times made.

12. *Construction of a t-node.* This is the converse of the process (11). The $(p-1)$-edron H' or H'' may be any autopolar whatever.

We consider first the case of a triangular Θ in the p-edron H.

At the θ'-node of the (p—1)-edron H', whatever θ' or H' may be, draw from either tip γ a line meeting the opposite side (3) in the triace $\theta=3$. This $\theta=3$ is the new nodal summit in the new nodal triangle $\Theta=3$, in our new p-edron, H, whose tips are $\gamma=\gamma'+1$, and $\lambda=\theta'=3$.

If Θ' in H' be a triangle, only two t-nodes can be built on it, of two p-edra H, one by the line just drawn, and another by such a line drawn from λ' in H', constructing a different $\Theta=3$.

13. But if $\Theta' > 3$ in H' we can construct, besides these two triangular Θ, others not triangles.

Let μ be any summit of Θ', not a tip. We can draw in

Θ' the diagonal $\theta'\mu$, and if we also draw its reciprocal, all will be autopolar. Instead of $\theta'\mu$, draw first $\Theta' M = \theta'' q$, partitioning θ', and adding an edge to Θ'. We can take our choice of joining μ and θ'', or μ and q, thus partitioning the augmented Θ' into Θ'_1 and Θ'_2, and adding an edge to θ'' or to q. The result is an autopolar p-edron, having for nodal face either $\Theta'_1 > 3$, containing the nodal summit $\theta'' + 1 = \Theta'_1$ or $\Theta'_2 > 3$, containing the nodal summit $q+1 = \Theta'_2$. In one case the new tips are $\mu + 1$ and q, in the other they are $\mu+1$ and θ''. The two sides in either case are the lines partitioning Θ' and θ' of H'.

This will be clearly enough seen by the reader, if he effects in ${}_{10}tb_{33}$ and in ${}_{10}tb_{34}$, figs. 207, 208, the reduction (11) of the 4-gonal t-node. He will see that a diagonal $\theta\mu$ has been drawn in two ways in the same subject 9-edron, to the same point μ. Two such t-nodes $\Theta'_1+1, > 3$, and $\Theta'_2+1, > 3$ can be obtained by a diagonal drawn from θ' to every different summit μ, which is not a tip, in the subject $\Theta' > 3$.

14. *Definition and reduction of a b-node.* A b-node has two triace tips $\gamma = \lambda = 3$ (8). It can be demonstrated of any b-node Θ on a p-edron K — 1st, that $\Theta > 3$ except in the 4-edron; 2nd, that the two by-walls (8) A and F of the node are not both triangles; 3rd, that whether there be one triangular by-wall or none, there is one side $\theta\ \lambda$ whose tip is in a non-triangular by-wall F, across which side there is no triangular section of the solid; 4th, that this side $\theta\ \lambda$ can be deleted, whence the by-wall F loses the triace λ, while $\theta\ \gamma$ the reciprocal of $\theta\ \lambda$ convanishes, whereby the by-tip f loses the triangle Λ; the result being an autopolar $(p-2)$-edron K', which may be of any species; 5th, that if K has no triangular by-wall, and if there be no triangular section of K across either $\theta\ \gamma$ or $\theta\ \lambda$, K is reducible in the same manner at the tip $\gamma = 3$ to one, and to one only autopolar $(p-2)$-edron K'', at the like cost to the by-wall A and the by-tip a. But if the

tip of a b-node in a non-triangular by-wall A is marked 3^i, (10), the b-node is not reducible at the by-tip a.

15. No b-node Θ of a p-edron K can be more than twice made. If Δ, as well as Θ in K, is a b-node, it is possible that K may be four times built in our processes, on four different $(p-4)$-edra. No such K can be more than four times made.

16. *Construction of a b-node.* This is the converse of the process in (14).

At either side of either node of any autopolar $(p-2)$-edron K', make between Θ' and Λ' a new $\Lambda=3$, augmenting θ' and adding $\gamma=3$ to the by-wall A' of K'. Then between θ' and λ' make a new $\lambda = 3$, augmenting Θ'_1 and adding $\Gamma = 3$ to the by-tip a' of Θ'. K' has become an autopolar p-edron K with a b-node.

If K' has four different nodal sides, four different b-nodes can be thus built of as many different p-edra K, whether Θ' in K' be a triangle or not. K' from symmetry may have fewer than four different *sides*.

17. *Definition and reduction of a w-node, or a wall-tip-built node.* A w-node Θ has one tip γ a triace, and the other λ no triace, but irreducible (11), by reason of a triangular section across the side $\theta\ \lambda$.

As in the node $\Theta = \gamma\ \theta\ \lambda\ .\ .\ .$ we call $\gamma\ \theta\ \lambda$ the nodal angle whose tips are γ and λ, so in the wall $\Gamma = \theta\ \lambda\ w.\ .\ .,$ $\theta\ \lambda\ w$ may be termed the wall-angle, of which θ and w are the tips, and in the wall $\Lambda = \theta\ \gamma\ v\ .\ .\ .$ we may call θ and v the wall-tips. But whenever we speak of a wall-tip we mean always either w or v, or the corresponding summits read from (3) in the walls of the node Δ.

As the tip-built node Θ was reduced (11) by lowering a tip, and the by-tip-built node Θ by lowering a by-tip (14); so we are about to see that the wall-tip-built node Θ is reduced by lowering a wall-tip.

18. The nodal signature of a w-node Θ in the p-edron L, is

$$\begin{array}{l} \Theta = \theta\ 3_1\ \mu\ .\ .\ .\ \gamma^i,\ (\gamma > 3);\ (\Theta > 3); \\ \qquad \Gamma\ W B\ .\ .\ F\ \mathbf{3}_1 \end{array}$$

where the i over γ denotes that the side $\theta\ \gamma$ is indelible by reason of a triangular section (10) of the solid across it. We may speak of such a tip γ^i, $(\gamma > 3)$ as of an indelible tip.

19. It can be demonstrated:—1st, that the by-wall W is no triangle; 2nd, that along the edge $3_1\mu = W\ \Theta$ there is no triangular section of L, and hence, 3rd, that $3_1\mu$ can convanesce (11), whereby W and Θ each lose an edge, and consequently that $w\ \theta = \mathbf{3}\ \mathbf{M}$ can be deleted, whereby w and θ each lose an edge; also the summits 3_1 and μ coalesce into a $(\mu+1)$-ace tip, while $\mathbf{3}_1$ and $\mathbf{M}$ unite into a $(\mathbf{M}+1)$-gonal wall.

The p-edron L, by the loss of the tip 3_1 and the wall $\mathbf{3}_1$, has become an autopolar $(p-1)$-edron L', whose nodal signature at its reduced Θ', which may or may not be a triangle, is

$$\begin{array}{l} \Theta'=\theta'\ (\mu+1)\ .\ .\ .\ \gamma^{i\,(w-1)},\ (\gamma>3), \\ \qquad \Gamma \qquad \mathbf{B}\ .\ .\ \mathbf{F}\ (\mathbf{M}+1) \end{array}$$

which is a t-node having no triace tip, but an indelible tip > 3, over which is written the wall-tip (17) in the wall

$$(\mathbf{M} + 1) = \theta'\ \gamma\ (w-1)\ .\ .\ .$$

For, in L, 3_1 is $\Theta\ \Gamma$ W, that is, $\mathbf{3}_1$ is $\theta\ \gamma\ w$, collateral with $\mathbf{M}$, because $3_1\mu$ is an edge of Θ. The deletion of the edge $\mathbf{3}\ \mathbf{M} = \theta w$ makes the enlarged face

$$(\mathbf{M} + 1) = (\theta-1)\ \gamma\ (w-1)\ .\ .\ .$$

The reciprocal $(\mathbf{W}-1)$ of this wall-tip of $\Lambda' = (\mathbf{M}+1)$ in Θ' is the tip-wall of $\lambda' = (\mu+1)$, in the $(p-1)$-edron L'. When Θ' above is a triangle, B and F are the same by-wall (9).

The triangular section across $\theta\gamma$ in L has not been disturbed by the vanishing of the edge $\mathbf{3}\ \mathbf{M} = \theta w$; it has

merely become a triangular section across $\Theta^1(\mathbf{M}+1)=\theta'\gamma$, of which the trace lies in $(\mathbf{M}+1)$ in which 3 of Θ is merged. That is, there is still the triangular section across $\theta'\gamma$ in L', and the tip is still γ^4 indelible in L'.

20. In (17) we said that the w-node Θ of L was reduced by lowering a wall-tip. We have lowered w, a by-tip of L. In every wall we can find both a wall-tip and a by-tip, which, when the wall is a triangle, and in that case alone, are the same summit of the solid.

This wall-tip $(w-1)$ over γ in L', on which the w-node of L is constructed, is always given in the t-nodal signature Θ'' in L'', the subject on which Θ' in L$'$ is built in our process. We never build a t-node Θ' but by augmenting a summit m of a subject node, under which m are written two faces containing m, of which the one that is not made a by-wall in the new t-node is the tip-wall, whose reciprocal is the wall-tip $(w-1)$ above named.

We call the above t-node Θ', carrying the wall-tip $(w-1)$, a *t-node under a wall-tip*. On such a t-node every w-node is constructed. We shall presently discuss the construction of w-nodes, and learn when the wall-tip is or is not to be superscribed.

21. There can be no other node-forms than three, viz., the t-node, which has at least one reducible tip, and may be a triangle Θ; the b-node, which has two triace tips and is no triangle Θ; and the w-node, no triangle Θ, which has one triace tip and one indelible tip (18).

Since every autopolar can be reduced without changing the number of its nodes, none can have more than two nodes; because the pyramid to which reduction must bring us has only two nodes.

It is possible so to name the faces of certain symmetrical autopolars that there shall seem to be more than two nodes. A 4-edron can have its faces so named. But this is a false

signature, made by misnaming faces A_1 A_2 A_3 . . . which have the same configuration.

It is important to remark that, after the construction of a node Θ of any form, every feature of the subject signature which is augmented by the operation, and is also a feature of Δ, must be augmented in the subject Δ; and if another feature augmented by an operation on the corrected Δ is read in the Θ just constructed, the like augment must be given after the operation to this feature in that Θ. This is perfectly simple when the nodal signatures are before us.

22. *The nine species of autopolars.* The names of the species are *tt*, *t*(*t*), *bb*, *b*(*b*) *ww*, *w*(*w*), *tb*, *tw*, *bw*. The first six have Θ and Δ of the same node-form; the other three have Θ and Δ of different node-forms.

23. *Definition, reduction, and construction of the species* (*tt*). The definition is, that either *t*-node of a *p*-edron ^{p}tt can be (11) reduced without destroying the *t*-form of the other node. Such a *p*-edron *H* can be reduced (11) by operations at both nodes, no matter in which order, to a (p—2)-edron H', which may be of any species; and on this H', *H* can be built (12) in one way only by operations at both nodes of H'.

We make the rule, that no $_{p}tt$ shall be constructed but by operation (12) (21) at both nodes of a (p—2)-edron. If *H* has more than one pair γ, ϕ, of reducible tips, it can be reduced to more than one H'. If $\gamma\phi$, $\gamma\,\pi$, $\lambda\phi$, $\lambda\pi$ are all reducible pairs, *H* can be reduced to H'_1 H'_2 H'_3 and H'_4, and on each of these four (p—2)-edra the *p*-edron *H* can be built in one way only.

24. The only possible reasons why $_{p}tt$ the *p*-edron *H* should not be reducible at the pair of tips γ, π, to a (p—2)-edron, are—

1st.—That one or both of γ, π, is a triace;

2nd.—That one or both is indelible (18);

3rd.—That, neither γ nor π being triace nor indelible, there is a quadrilateral section across $\theta\gamma$ and $\delta\pi$.

The deletion in such case of *both* will introduce a linear section, Q. E. A.

The sides $\theta\gamma$ and $\delta\pi$ are in this case called a pair of semi-indelible sides, and we call γ and π semi-indelible tips, and write γ^s and π^s in the nodal signatures. There may be two pairs of semi-indelible tips, $\gamma\pi$ and $\gamma\phi$, or $\gamma\pi$ and $\lambda\phi$, in which case we write $\gamma^{ss'}$, π^s, and $\phi^{s'}$; or γ^s, π^s, and $\lambda^{s'}$, $\phi^{s'}$. The first condition allows only $\lambda\pi$ and $\lambda\phi$, the second allows only $\gamma\phi$ and $\lambda\pi$, to be reducible pairs.

25. There is a number of little theorems about indelible and semi-indelible sides, with which I shall not here trouble the reader. It may suffice to lay down the leading principles.

1st. The conditions necessary and sufficient that γ^i shall stand in a nodal signature is, that there be an edge e or a face F of the solid, which has a summit of Θ and a summit of Λ. For a triangular section across $\theta\gamma = \Theta\Lambda$ must traverse F or contain e.

2nd. A quadrilateral section across $\theta\gamma = \Theta\Lambda$ and $\delta\pi = \Delta\Phi$ is a section through the faces Θ Λ Δ Φ in that order, or else in the order Θ Λ Φ Δ.

The condition necessary and sufficient that there shall be the former section is that Λ and Δ shall have a common summit, and that Θ and Φ shall have a common summit.

The condition necessary and sufficient that there shall be the latter section is, that Λ and Φ shall have, and that Δ and Θ shall have, a common summit.

26. There is never any doubt about the right number or names of indelible or semi-indelible tips, in a constructed p-edron ${}_ptt$, H. The nodal signatures of the $(p-2)$-edron on which H is built always supply the required information. If there be a suspension of judgment, to be indicated by a (?)

in our register, it is always connected with symmetry not yet decided, and must disappear as soon as we have completed our tables of the symmetrical autopolar p-edra. The questions of symmetry belong to the general theory, and are far from simple. It will be observed that every figured autopolar is marked m_1, m_2, or m_3. This means once reducible or once *made*, or twice, or thrice, reducible and *made*. No autopolar can be more than four times made. None of the figures given carry m_4. The mark is frequent enough in the higher solids.

There is one indelible tip in ${}_8tt_{10}$, fig. 19; there are two in ${}_{10}tt_{74}$, fig. 192. There is a pair of semi-indelible sides in the asymmetric ${}_{10}tt_{104}$, fig. 238, and two pairs in the symmetric ${}_{10}tt_{14}$, fig. 103. I have met with no asymmetric having two pairs of semi-indelibles; but I have knowledge of their frequency as solids beyond the 10-edra.

27. *Definition, reduction, and construction of the species* ${}_pt(t)$. The definition of a p-edron ${}_pt(t)$, K, is that neither of its t-nodes can be reduced (11) without changing the other node into a b-node, or a w-node. From this it follows that K has either only one reducible tip which is a 4-ace common to both nodes, or that the only reducible tips are in a pair of semi-indelible sides in Θ and Δ. Examples are ${}_{10}t(t)_1$, ${}_{10}t(t)_2$, and ${}_{10}t(t)_3$. The constructions of the species ${}_pt(t)$ all arise in the working of this rule—that we construct on every $(p-1)$-edron which is not a ${}_{p-1}tt$ nor a ${}_{p-1}t(t)$ every possible t-node which does not make a ${}_ptt$; for the construction of a ${}_ptt$ on a $(p-1)$-edron is forbidden by the rule in (23). The nodal signatures of the subject $(p-1)$-edron always inform us when a ${}_pt(t)$ is constructible, and always warn us correctly against the error of making a ${}_ptt$ on the $(p-1)$-edron.

28. *The definition, reduction, and construction of the species* ${}_pbb$. The definition is that the p-edron ${}_pbb$ shall have two b-nodes, either of which θ can be reduced (14) without

destroying the b-form of the other δ or changing the number δ.

Every ${}_{p}bb$, K can be reduced by the process of (14) applied to both nodes once, in either order, to a $(p-4)$-edron, which may be of any species. If K has in each node two non-triangular by-walls, and has no indelible tip 3^{i}, nor a symmetry, it can be reduced to four different $(p-4)$-edra, which may be of any species.

This is saying that on every $(p-4)$-edron of any species, from one to four different ${}_{p}bb$ can be constructed (16); and we make the rule never to construct a ${}_{p}bb$ except upon a $(p-4)$-edron, and never except by operation (16) (21) on a by-tip of each node. A ${}_{p}bb$ may be once made or more than once made, but not more than four times made. This depends on symmetry.

We know always from the subject and constructed nodal signatures whether m_1, m_2, m_3 or m_4 is to be written (26).

29. *The species* ${}_{p}b(b)$. The definition of a ${}_{p}b(b)$ p-edron is, that neither of its b-nodes can be reduced (14) without reducing the other. This is saying that either nodal summit is the only by-tip > 3 of the other node. There is one and one only ${}_{p}b(b)$ when p is even and > 4; there is none when p is odd. A ${}_{p}b(b)$ is always built on a ${}_{p-2}b(b)$ in one way only.

The considerations about semi-indelibles (24, 25) do not apply here.

30. *Definition, reduction, and construction of the species* $w(w)$. A p-edron ${}_{p}w(w)$ has two w-nodes, and its definition is that the two triace tips (17) are in an edge. It can be reduced at either node (19), and it can be demonstrated that one reduction, and only one, is to a ${}_{p-1}t(t)$ *under a wall-tip* (20), or *under wall-tips*, one in each node. We decide that this shall be the proper reduction, the other being improper. ${}_{p}w(w)$ reduces only to one ${}_{p-1}t(t)$.

31. The $t(t)$ *under a wall-tip* (20) has a reducible (11)

4-ace tip $\lambda=4=\pi$, common to the nodes, and an indelible tip γ^{ϕ}, where $\gamma > 3$, and the wall-tip 3 is the triace tip ϕ.

The $t(t)$ *under wall-tips* has the common tip $\lambda=4=\pi$, and two indelible tips, $\gamma^{t\phi}$ and $\phi^{t\gamma}$, where $\gamma > 3$ and $\phi > 3$ are both tips and wall-tips.

The number of solids $_{p}w(w)$ is exactly that of these $_{p\text{-}1}t(t)$ (30), and every $_{p}w(w)$ is built only on one $_{p\text{-}1}t(t)$, which is ready for inspection in our tables of autopolar $(p-1)$-edra.

32. *Definition, reduction, and construction of the species ww.* The $_{p}ww$ is defined as having (17) its two triace tips not in one edge.

Every $_{p}ww$ reduces, by operation at both nodes, no matter at which node we begin the reduction (19), to one, and to one only, $_{p\text{-}2}tt$ *under wall-tips*, one in each node (20). This $_{p\text{-}2}tt$ has no triace tip, and has an indelible tip in each node. Its nodes may or may not have a common tip, and may or may not have a common summit.

Every $_{p\text{-}2}tt$ which has no triace tip, and has two indelible tips, and which has for neither wall-tip a tip, and has not two by-tips for its wall-tips, is a $_{p\text{-}2}tt$ under wall-tips. The only $_{10}tt$ *under wall-tips* is $_{10}tt_{74}$ (fig. 142).

In our constructions of the species tt we can always either write or omit the wall-tip $(w-1)$ over the tip π^{t} not augmented; for $(w-1)$ is a number read in the subject nodal signature (20). The definition just given decides when $(w-1)$ is to be superscribed.

The number of the $_{p}ww$ is exactly that of the $_{p\text{-}2}tt$ under wall-tips, on each of which, by operation at both nodes, we build one, and only one, $_{p}ww$. This operation, the reverse of the reduction (19), is merely drawing in each node Θ an edge $(\theta+1)w$ from the nodal summit to the wall-tip, and next, the reciprocal edge $(\Theta+1)W$.

We never construct a w-node, except when we build a $_{p}w(w)$ on a $(p-1)$-edron, or a $_{p}ww$ on a $(p-2)$-edron. No $_{p}w(w)$ or $_{p}ww$ is twice made.

33. *Definition and construction of the species tb and tw.* A *tb* is always reducible at its *t*-node (11) to an autopolar (p–1)-edron. The same is true of the species $_ptw$, and either may be once or twice made at its *t*-node, according as the latter has or has not two reducible tips.

We make the rule never to build a *tb* at its *b*-node, nor a *tw* at its *w*-node, because both are certain to be constructed at the *t*-node. The constructions *tb* and *tw* all arise in their proper forms and places, in the working of the rule given in (27); and all the information that we require is before us in the subject nodal signatures, far more clearly that it can be in linear constructions.

34. *The species bw.* Every p-edron *bw* can be reduced in one or in two ways at its *b*-node to a (p–2)-edron (14).

We can demonstrate by the help of what we have proved concerning the form of a reduced *w*-node (19), that every $_pbw$ must be brought by successive reductions at the *b*-node to $_8bw$, which by one more reduction becomes the pyramid 6-edron.

Wherefore all the p-edra $_pbw$ are the progeny, by successive *b*-operations at the *b*-node, of $_8bw$.

We never build a *tw* or a *bw* at its *w*-node, because it is certain to be constructed and properly registered from operation at the other node.

35. It will be observed that a number of the figured autopolars are twice drawn, with different nodal faces, and, therefore, will give each two forms of nodal signatures.

This two-fold nodal signature belongs to every autopolar which has a 2m-ple repetition about a zoneless axis, and also to every 2m-zoned autopolar in which the two zones are both autopolar, and not one the reciprocal of the other. See $_8tt_2 = {}_8bb_1$ (figs. 28, 29), $_{10}bb_1 = {}_{10}bb_2$ (figs. 90, 91), and all the zoneless 2-ples. Both the nodal signatures of such an autopolar have to be employed as subjects of operation for higher autopolars; for there are solids which are reducible to every

such subject under one of its signatures, and not under the other.

36. All nodal autopolar p-edra can be enumerated and registered with their nodal and tabular signatures, and with an account of their symmetry, from inspection of the like signatures of the lower autopolars. The information required for this enumeration and description of higher solids is obtained from the subject signatures with greater ease and certainty than from any inspection of the figured subjects. There is no need of a single linear construction.

37. When the future student comes to write out the nodal and tabular signatures of the solids which I have figured, a thing which must be done for expeditious continuation of the work, he will find that they are most of them, but not all, groups of one. I am confident that if the tabulation be continued to greater values of p, the proportion of groups of one will diminish in the autopolar p-edra, and that there will be groups of scores and of hundreds.

In what is here figured there are many groups of two, and ${}_{10}tt_{95}$, ${}_{10}tt_{96}$, ${}_{10}tt_{97}$ (figs. 229, 230, 231), are a group of three having the same nodal and tabular signatures; also ${}_{10}tt_{36}$, ${}_{10}tt_{37}$, and ${}_{10}tt_{51}$ (figs. 138, 141, 155), are a group of three.

On every one of such a group constructions are effected by one thought, and registered in one entry. This suffices for specific enumeration and description. Actual separate construction in linear figures may be a more formidable task, in the cases of such groups.

In the plates the asymmetric solids are so grouped that those of the same tabular signatures stand together. What precedes may suffice for nodal autopolars.

38. *Enodal autopolars.* Every $(2m+1)$-zoned nodal autopolar whose nodal summits are not zonèd, can receive an enodal signature.

If in the like faces or either side of the zonal trace we

exchange their names, the names of the summits being undisturbed, the two nodes will disappear, but all will still be autopolar.

On every enodal zoned autopolar S reciprocal pairs of edges may be drawn, the diagonal $A\,B\,c\,d$ (1) corresponding with its reciprocal or *gamic*, as I have elsewhere called it, in a partitioned summit, of which pairs some will destroy the zonal symmetry of the solid S.

It can be demonstrated from the known number of effaceables $A\,B\,c\,d$ that can be drawn in the autopolar enodal zoned 8-edra, that there are no enodal autopolar asymmetric 9-edra ; and by like reasoning on the drawable effaceables of the enodal zoned 9-edra, compared with the enodal zoned 10-edra, it can be proved that there must be enodal asymmetric 10-edra.

I know of no method of enumerating and describing the enodal asymmetric p-edra, besides that of drawing leading effaceables (*vide* p. 217 of Vol. XXXII.) in the enodal $(p-1)$-edra. By this method, when the enodal 9-edra are drawn, it is easy to prove that the only asymmetric enodal 10-edra are the two last figured, figs. 252, 253. I have proved by trial that this method of studying the nodal autopolars is both roundabout and risky. The method may yield more rapid results, when a dozen or two of theorems have been placed on record for the expediting of it. Any student who fancies the subject can do this.

39. This problem of the autopolar p-edra is no essential part of the question of the accurate enumeration and description of the p-edral q-acra. It is a small fraction of the problem of the p-edral p-acra, and a very minute fraction of the problem of the p-edra. In my general theory of the p-edral q-acra I have given no theorems without demonstration. In this last and little chapter, I have contented myself with simply enunciating a number of small propositions.

This is the wisest thing that I can do; because it has been decided, by scientific authority from which there is no appeal, that the English tongue is yet too youthful to be entrusted with the full exposition of the extensive theory of the polyedra.

This paper would have been five or six times as long, if it had contained explicitly the work done on nodal signatures which is compressed into the figures, with clear demonstration and illustration of all the theorems. And it is millions to one that it would have found no real reader for the next lifetime. Still less do I believe it will find such a reader, as it is.

40. I have what appears to me to be rigorous demonstration of everything that I have said in this short paper. But it would ill become me to affirm with assurance that in the geometrical analysis of so dense a cobweb I have committed neither violence nor oversight.

This I leave to be decided by the future student in days when this province of Philosophy without Assumptions, Geometry at the very beginning in space of three dimensions, shall come into fashion among dynamists who are tired of talking learnedly, with La Place and others, about forces which act at insensible distances, and which may therefore be disregarded.

41. That future student of autopolars will find himself demonstrating a hatful of little theorems about tips and by-walls, and edges delible, indelible, and semi-indelible.

Whether he satisfies himself or no that he is the first to demonstrate them, I wish him ten times the glory and the profit which they may bring him.

If it be quite certain, as I suppose it is, that there is no single force acting in this inferior bodily Cosmos, which does not act from a definite point upon another definite point in a definite right line, by a law dependent on the distance between the points which is never zero, it may come to be

evident, although I confess that I cannot clearly conceive how, that this complete theory of the polyedra is a necessary introduction to dynamical science yet undiscovered. One thing I venture to affirm—that the distinction in real science, about which I have heard the learned refine, between molar and molecular forces, is very good moonshine.

42. Philosophers have been so successful as to find out something about one—let us put it on an average, for numerical precision, one—of the uncounted and may be countless laws of force which are in action around us, the law of gravitation. We have luckily been placed inside one of the molecules in which that force is working, and endowed with powers adequate to rough observation and measurement therein. We have not yet got far enough into the mystery of a falling stone to decide, whether there be something acting between the stone and the earth which pulls them together, or something not acting between them which pushes them together.

That is a very sore little point with us; but, fortunately, we manage to keep it a good deal out of sight. And nobody doubts that we are prodigiously learned in the secrets of nature. For look how grandly we can talk about matter and law—this Realm of Matter and this Reign of Law!—or, more accurately, this Realm of Rubbish, and this Majesty of Must-be, a deity as worshipful as the fetish of the Bushman.

I do not believe that I am for ever to be kept out of all the other molecules, and to remain as helpless as I now am, in guessing at what goes on inside them. I believe that I shall be yet permitted to observe and to measure with an accuracy beyond my present powers to conceive, and even to discover that my theorems about polyedra are, after all, quite useful knowledge. But this I presume can be only in some brighter planet, about some nobler sun.

Description of the Figures,

with the tabular signatures of the solids :—

Autopolar 6-Edron.

Figs. 1, 2. One 2-ple zoneless monaxine heteroid; $4^2 3^2 3^2 = 1$
Heteroid means not janal.

Autopolar 7-Edra.

Figs. 3, 4.	Two 3-zoned monaxine heteroids;	$4^3 3 3^3 = 2$
„ 5, 6.	One 2-ple zoneless monax. het.,	$4 4^2 3^2 3^2 = 1$
„ 7, 8.	Two asymmetricals,	$4^3 3^4 = 1$
		$5 4 3^5 = 1$

In the tabular signature of a symmetrical autopolar, A^m stands for m A-gons of the same configuration; in that of an asymmetrical, for m A-gons all of different configuration.

Autopolar 8-Edra.

Fig. 9.	One zoned triaxine, janal,	$4^4 3^4 = 1$
„ 10.	One monozone,	$5 3 4^2 3^2 3^2 = 1$
„ 11...16.	Three 2-ple zoneless monax. het.,	$4^2 4^2 3^2 3^2 = 2$
		$5^2 3^2 3^2 3^2 = 1$
„ 17...26.	Ten asymmetricals;	$6 4 3^6 = 1$, $5^2 3^6 = 7$, $4^4 3^4 = 2$

Autopolar 9-Edra.

Figs. 27...29.	Two 4-zoned monaxine heteroids,	$4 4^4 3^4 = 2$
„ 30...37.	Four 2-ple zoneless monax. het.,	$6 4^2 3^2 3^2 3^2 = 1$
		$4 5^2 3^2 3^2 3^2 = 1$
		$4 4^2 4^2 3^2 3^2 = 2$
„ 38...41.	Four monozones,	$6 3 3 4^2 3^2 3^2 = 1$
		$5 4 3 4^2 3^2 3^2 = 3$
„ 42...80.	Thirty-nine asymmetricals;	

$7 4 3^7 = 1$, $6 5 3^7 = 1$, $6 4^2 3^6 = 6$, $5 4^3 3^6 = 27$, $4^5 3^4 = 4$

AUTOPOLAR 10-EDRA.

Figs. 81, 82. Two janals; one zoneless triaxine, $4^2 4^4 3^4 = 1$
one janal anaxine; $5^2 4^2 3^2 3^2 3^2 = 1$
" 83, 84, 85. Three 3-zoned monaxine het., $35^3 3^3 3^3 = 1$
$34^3 4^3 3^3 = 2$
Figs. 86, 87, 88. Three 3-ple zoneless monaxines;
$35^3 3^3 3^3 = 1$
$34^3 4^3 3^3 = 1$
$64^3 3^3 3^3 = 1$
" 89, 90, 91. Two 2-zoned monaxine het., $5^2 4^2 3^2 3^2 3^2 = 2$
" 92...111. Ten 2-ple zoneless monax. het., $6^2 3^2 3^2 3^2 3^2 = 1$
$5^2 4^2 3^2 3^2 3^2 = 5$
$4^2 4^2 4^2 3^2 3^2 = 4$
" 112...118. Seven monozones, $534^2 4^2 3^2 3^2 = 1$
$535^2 3^2 3^2 3^2 = 1$
$554^2 3^2 3^2 3^2 = 1$
$784^2 3^2 3^2 3^2 = 1$
$44334^2 4^2 3^2 = 2$
$44335^2 3^2 3^2 = 1$

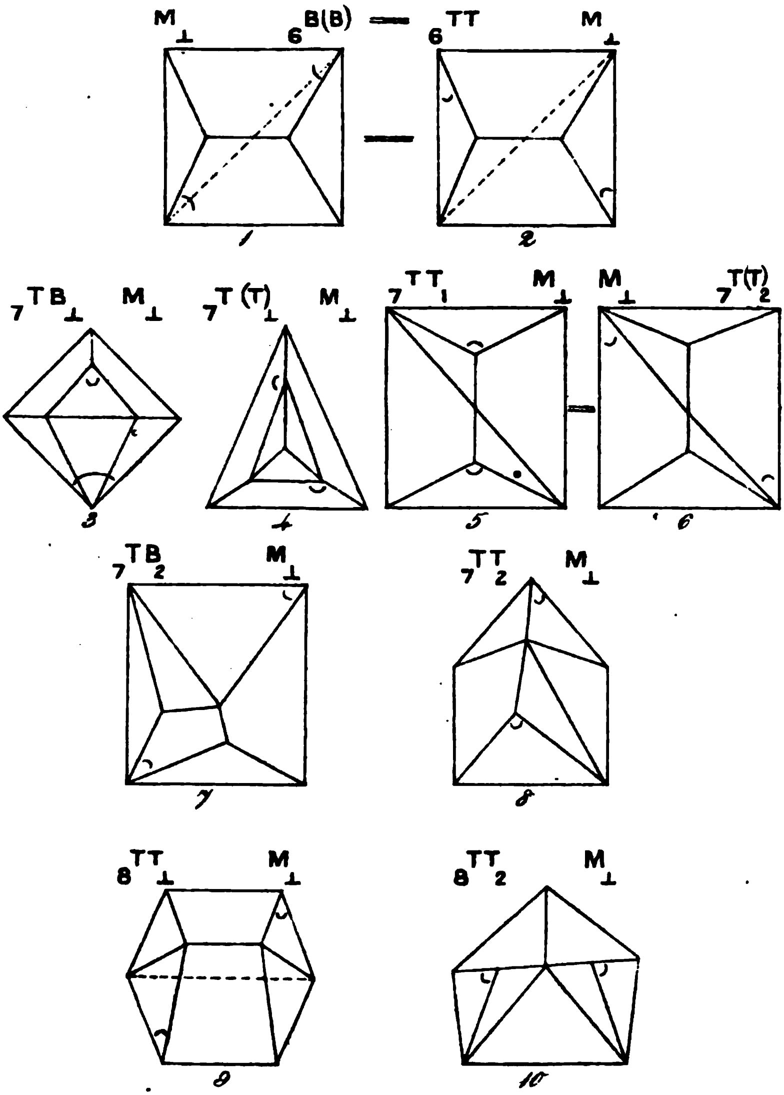
ONE HUNDRED AND THIRTY-THREE NODAL ASYMMETRIC 10-EDRA.

Fig. 119. $843^8 = 1$;
" 120. $753^8 = 1$;
" 121...126. $74^2 3^7 = 6$;
" 127...135. $6543^7 = 9$;
" 136...156. $64^3 3^6 = 21$;
Fig. 157, 158. $5^3 3^7 = 2$;
" 159...194. $5^2 4^2 3^6 = 36$;
" 195...246. $54^4 3^5 = 52$;
" 247...251. $4^6 3^4 = 5$.

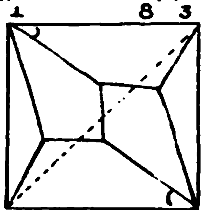
TWO ENODAL ASYMMETRIC 10-EDRA.

Fig. 252. $64^3 3^6 = 1$; Fig. 253. $54^4 3^5 = 1$.

THE AUTOPOLAR POLYEDRA OF FEWER THAN ELEVEN FACES.

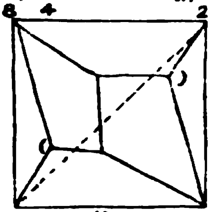


$M_{\perp}$ 8^{TT_3}



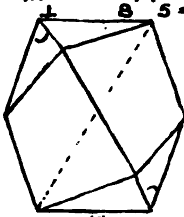
11

8^{TT_4} M_2

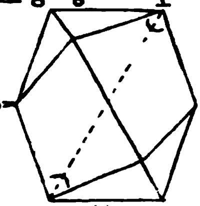


12

$M_{\perp}$ $8^{TT_5} = 8^{TT_6}$ $M_{\perp}$

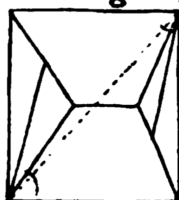


13

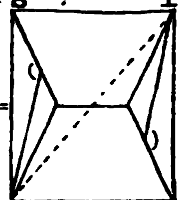


14

$8^{B(B)} = 8^{TT_7}$ $M_{\perp}$

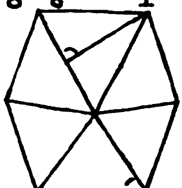


15



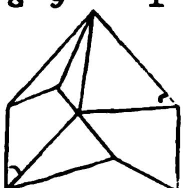
16

8^{TT_8} $M_{\perp}$



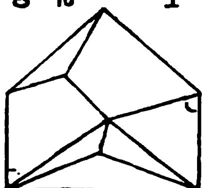
17

8^{TT_9} $M_{\perp}$



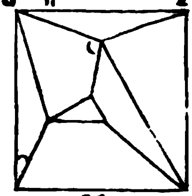
18

$8^{TT_{10}}$ $M_{\perp}$



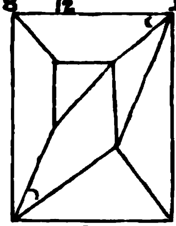
19

$8^{TT_{11}}$ M_2



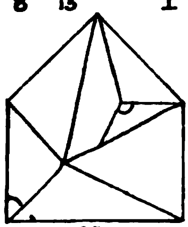
20

$8^{TT_{12}}$ $M_{\perp}$



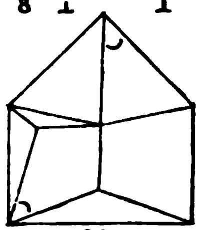
21

$8^{TT_{13}}$ $M_{\perp}$



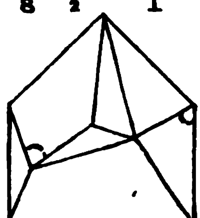
22

$8^{TB_{\perp}}$ $M_{\perp}$



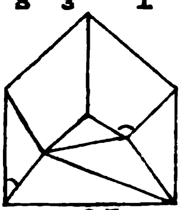
23

8^{TB_2} $M_{\perp}$



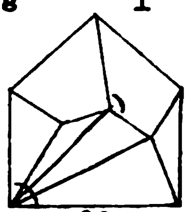
24

8^{TB_3} $M_{\perp}$



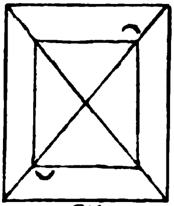
25

8^{BW} $M_{\perp}$



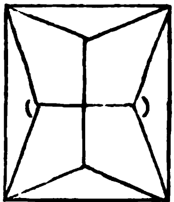
26

$9^{TT}{}_{\perp}$ $M_{\perp}$

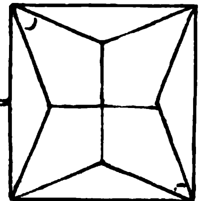


27

$9^{TT}{}_{2}$ $M_{2} = 9^{BB}$

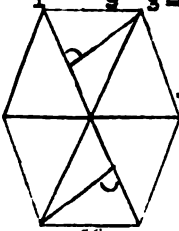


28

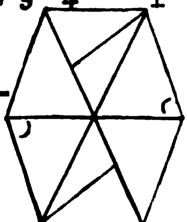


29

$M_{\perp}$ $9^{TT}{}_{3} = 9^{TT}{}_{4}$ $M_{\perp}$

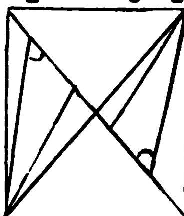


30

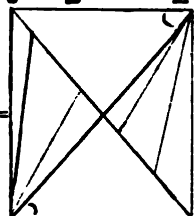


31

$M_{\perp}$ $9^{TT}{}_{5} = 9^{T(T)}{}_{\perp}$ $M_{\perp}$

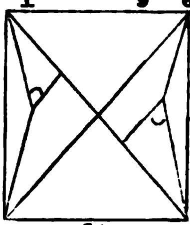


32

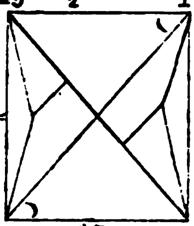


33

$M_{\perp}$ $9^{TT}{}_{6} = 9^{T(T)}{}_{2}$ $M_{\perp}$

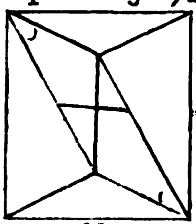


34

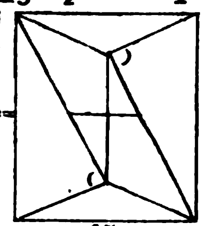


35

$M_{\perp}$ $9^{TT}{}_{7} = 9^{BB}{}_{2}$ $M_{\perp}$

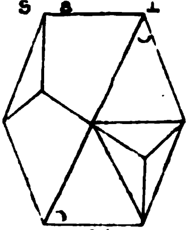


36



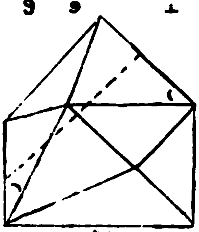
37

$9^{TT}{}_{8}$ $M_{\perp}$



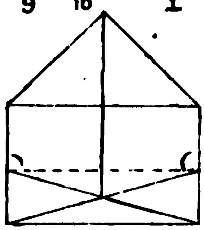
38

$9^{TT}{}_{9}$ $M_{\perp}$



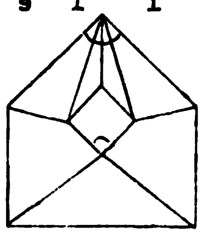
39

$9^{TT}{}_{10}$ $M_{\perp}$



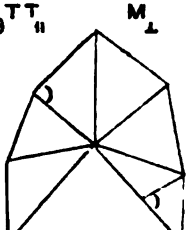
40

$9^{TB}{}_{\perp}$ $M_{\perp}$



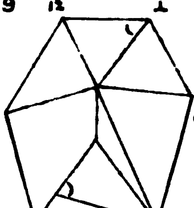
41

$9^{TT}{}_{11}$ $M_{\perp}$



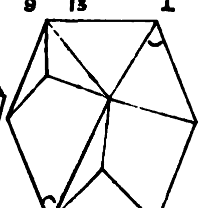
42

$9^{TT}{}_{12}$ $M_{\perp}$



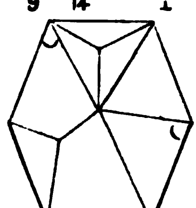
43

$9^{TT}{}_{13}$ $M_{\perp}$



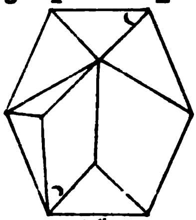
44

$9^{TT}{}_{14}$ $M_{\perp}$



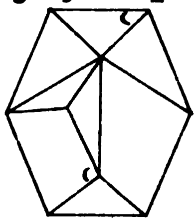
45

9^{TB_2} $M_{\perp}$



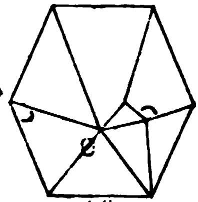
46

9^{TB_3} $M_{\perp}$



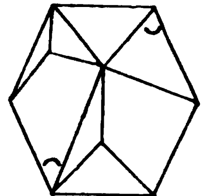
47

9^{TB_4} $M_{\perp}$



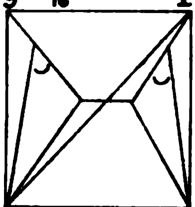
48

$9^{TT_{15}}$ $M_{\perp}$



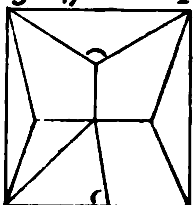
49

$9^{TT_{16}}$ $M_{\perp}$



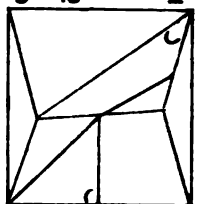
50

$9^{TT_{17}}$ M_2



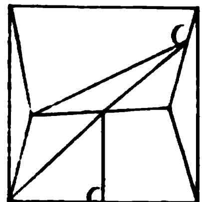
51

$9^{TT_{18}}$ $M_{\perp}$



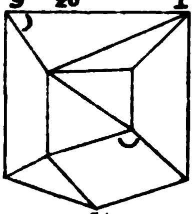
52

$9^{TT_{19}}$ M_2



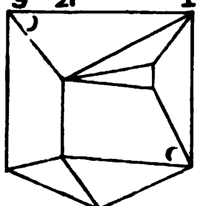
53

$9^{TT_{20}}$ $M_{\perp}$



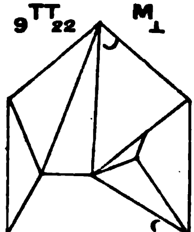
54

$9^{TT_{21}}$ $M_{\perp}$



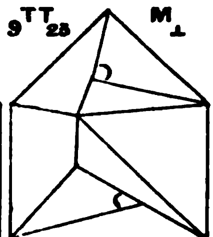
55

$9^{TT_{22}}$ $M_{\perp}$



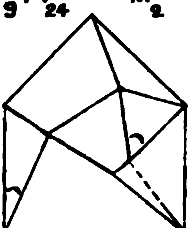
56

$9^{TT_{23}}$ $M_{\perp}$



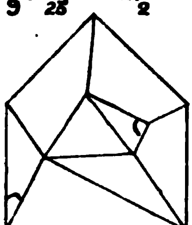
57

$9^{TT_{24}}$ M_2



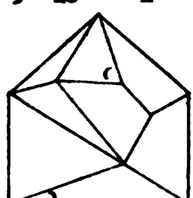
58

$9^{TT_{25}}$ M_2



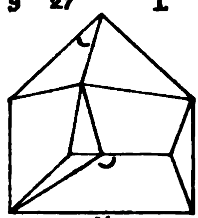
59

$9^{TT_{26}}$ M_2



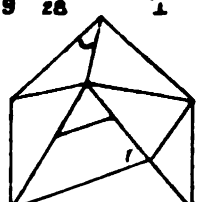
60

$9^{TT_{27}}$ $M_{\perp}$



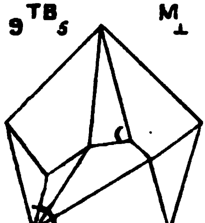
61

$9^{TT_{28}}$ $M_{\perp}$



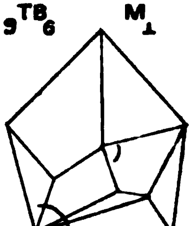
62

9^{TB_5} $M_{\perp}$



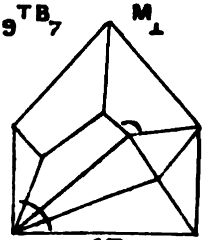
63

9^{TB_6} $M_{\perp}$



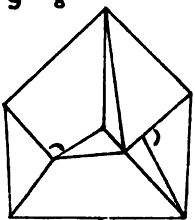
64

9^{TB_7} $M_{\perp}$



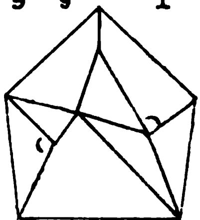
65

9^{TB}_{8} M



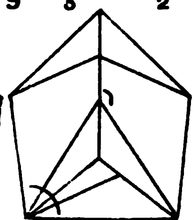
66

9^{TB}_{9} $M_{\perp}$



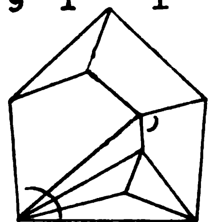
67

$9^{T(T)}_{3}$ M_{2}



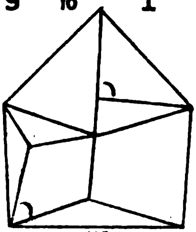
68

$9^{TW}_{\perp}$ $M_{\perp}$



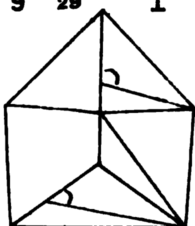
69

9^{TB}_{10} $M_{\perp}$



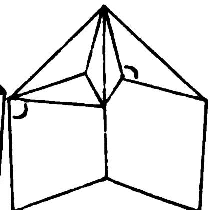
70

9^{TT}_{29} $M_{\perp}$



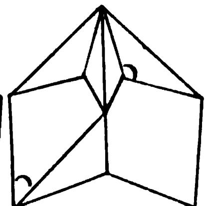
71

9^{TT}_{30} $M_{\perp}$



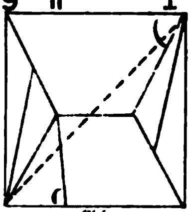
72

9^{TT}_{31} $M_{\perp}$



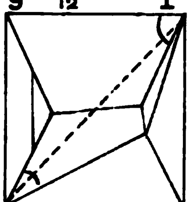
73

9^{TB}_{11} $M_{\perp}$



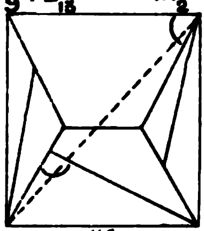
74

9^{TB}_{12} $M_{\perp}$



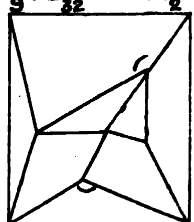
75

9^{TB}_{13} M_{2}



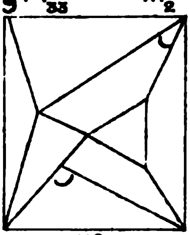
76

9^{TT}_{32} M_{2}



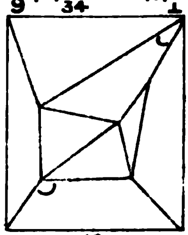
77

9^{TT}_{33} M_{2}



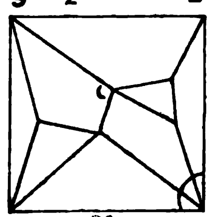
78

9^{TT}_{34} $M_{\perp}$



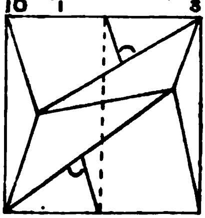
79

9^{TW}_{2} $M_{\perp}$



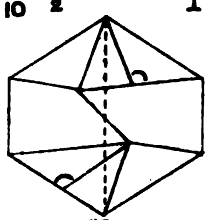
80

10^{TT}_{1} M_{3}



81

10^{TT}_{2} $M_{\perp}$



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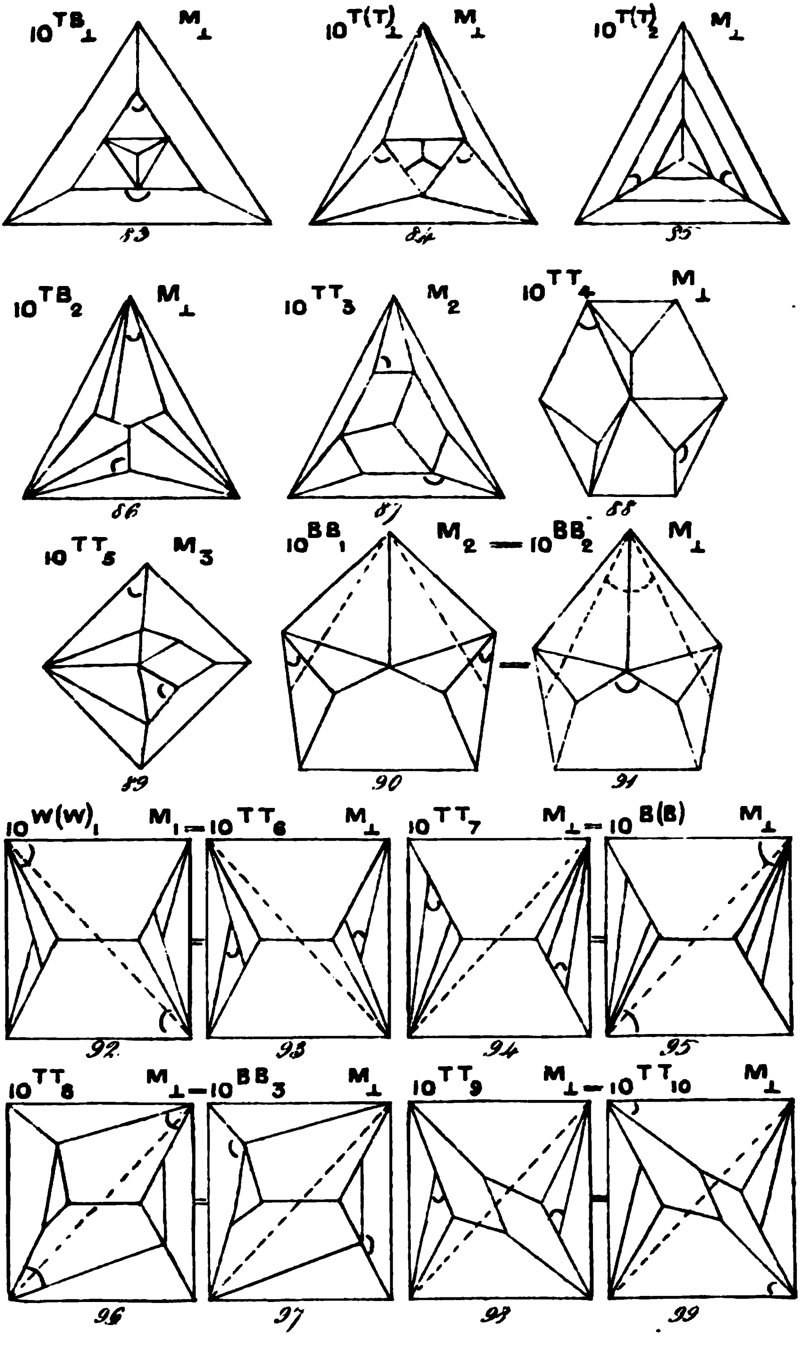
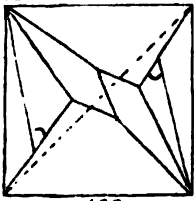


10 TB ⊥ M ⊥
10 T(T) ⊥ M ⊥
10 T(T) 2 M ⊥
83
84
85
10 TB 2 M ⊥
10 TT 3 M 2
10 TT 4 M ⊥
86
87
88
10 TT 5 M 3
10 BB 1 M 2 = 10 BB 2 M ⊥
89
90
91
10 W(W) 1 M 1 = 10 TT 6 M ⊥
10 TT 7 M ⊥ = 10 B(B) M ⊥
92
93
94
95
10 TT 8 M ⊥ = 10 BB 3 M ⊥
10 TT 9 M ⊥ = 10 TT 10 M ⊥
96
97
98
99

$10^{TT}{}_{11}$ $M_{\perp}$ = $10^{TT}{}_{12}$ $M_{\perp}$ $10^{TT}{}_{15}$ $M_{\perp}$ = $10^{TT}{}_{14}$ M_{2}



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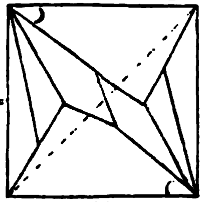

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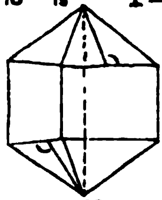

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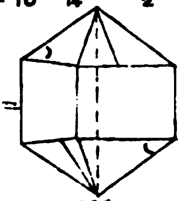
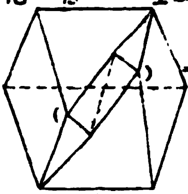


103

$10^{TT}{}_{15}$ $M_{\perp}$ = $10^{T(T)}{}_{3}$ $M_{\perp}$ $10^{TT}{}_{16}$ $M_{\perp}$ = $10^{TT}{}_{17}$ M_{2}



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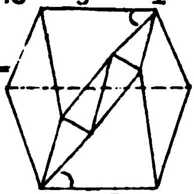

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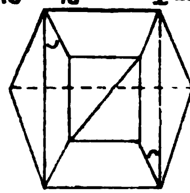

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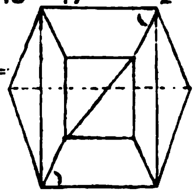
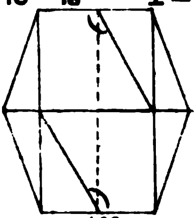


107

$10^{TT}{}_{18}$ $M_{\perp}$ = $10^{TT}{}_{19}$ $M_{\perp}$ $10^{TT}{}_{20}$ $M_{\perp}$ = $10^{TT}{}_{21}$ $M_{\perp}$



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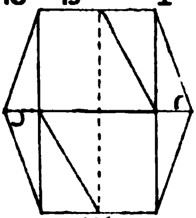

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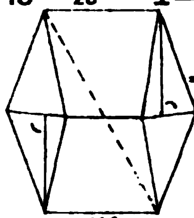

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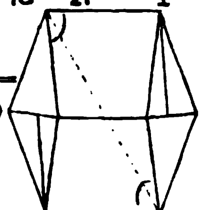
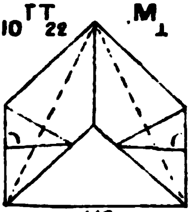


111

$10^{TT}{}_{22}$ $M_{\perp}$ $10^{T4}{}_{23}$ $M_{\perp}$ $10^{TT}{}_{24}$ $M_{\perp}$ $10^{TT}{}_{25}$ $M_{\perp}$



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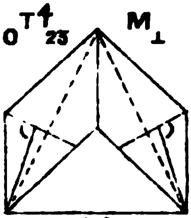

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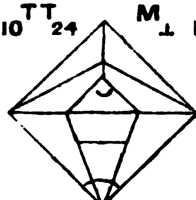

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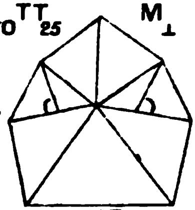
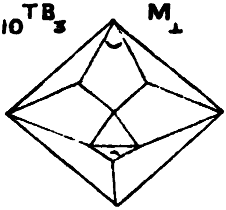


115

$10^{TB}{}_{3}$ $M_{\perp}$ $10^{BB}{}_{4}$ $M_{\perp}$ $10^{T(T)}{}_{4}$ $M_{\perp}$



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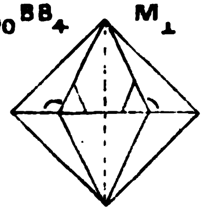

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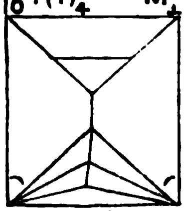
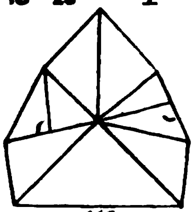


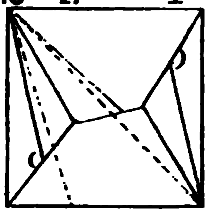
118

10^{TT}_{26} $M_{\perp}$



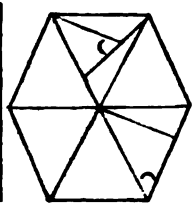
119

10^{TT}_{27} $M_{\perp}$



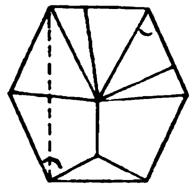
120

10^{TT}_{28} $M_{\perp}$



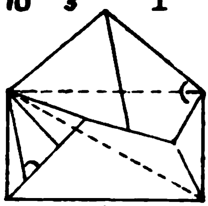
121

10^{TB}_{4} $M_{\perp}$



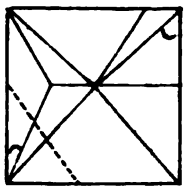
122

10^{TB}_{5} $M_{\perp}$



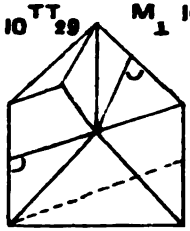
123

10^{TB}_{6} $M_{\perp}$



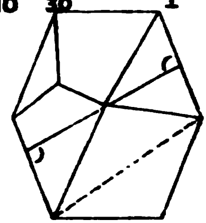
124

10^{TT}_{29} $M_{\perp}$



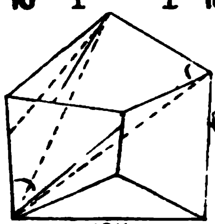
125

10^{TT}_{30} $M_{\perp}$



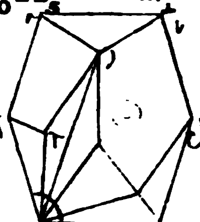
126

$10^{BW}_{\perp}$ $M_{\perp}$



127

10^{BB}_{5} $M_{\perp}$



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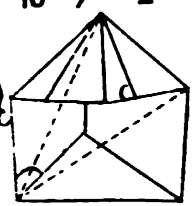
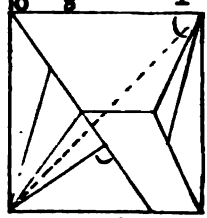
10^{TB}_{7} $M_{\perp}$



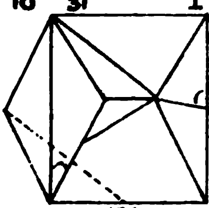
129

10^{TB}_{8} $M_{\perp}$



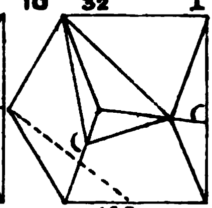
130

10^{TT}_{31} $M_{\perp}$



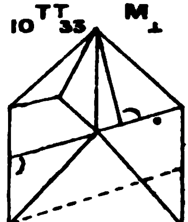
131

10^{TT}_{32} $M_{\perp}$



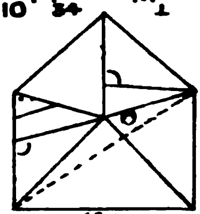
132

10^{TT}_{33} $M_{\perp}$



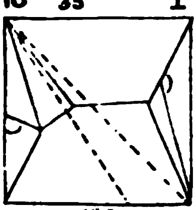
133

10^{TT}_{34} $M_{\perp}$



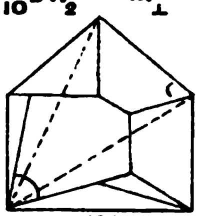
134

10^{TT}_{35} $M_{\perp}$



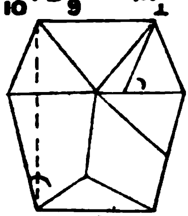
135

10^{BW}_{2} $M_{\perp}$



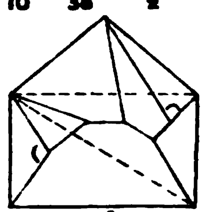
136

10^{TB}_{9} $M_{\perp}$



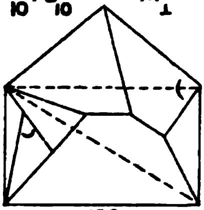
137

10^{TT}_{36} M_{2}



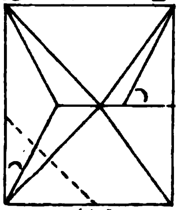
138

$10^{TB}{}_{10}$ $M_{\perp}$



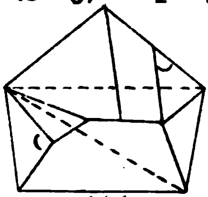
139

$10^{TB}{}_{11}$ $M_{\perp}$



140

$10^{TT}{}_{37}$ M_{2}



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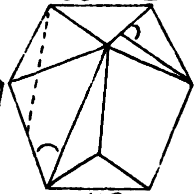
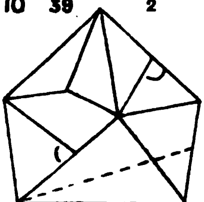
$10^{TT}{}_{38}$ $M_{\perp}$



142

$10^{TT}{}_{39}$ M_{2}



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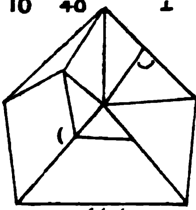
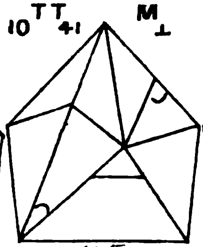
$10^{TT}{}_{40}$ $M_{\perp}$



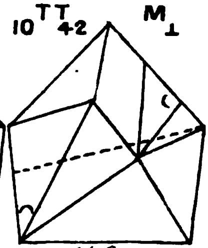
144

$10^{TT}{}_{41}$ $M_{\perp}$



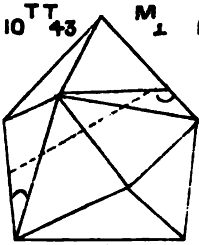
145

$10^{TT}{}_{42}$ $M_{\perp}$



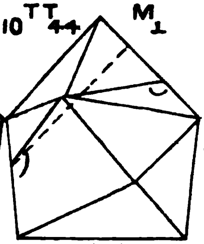
146

$10^{TT}{}_{43}$ $M_{\perp}$



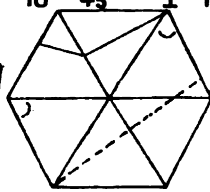
147

$10^{TT}{}_{44}$ $M_{\perp}$



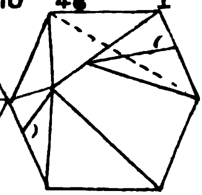
148

$10^{TT}{}_{45}$ $M_{\perp}$



149

$10^{TT}{}_{46}$ $M_{\perp}$



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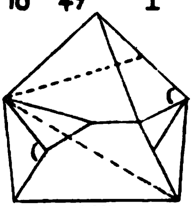
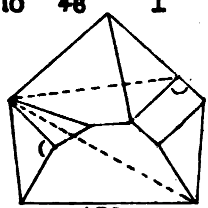
$10^{TT}{}_{47}$ $M_{\perp}$



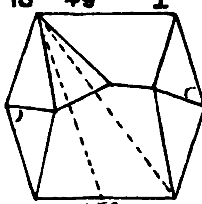
151

$10^{TT}{}_{48}$ $M_{\perp}$



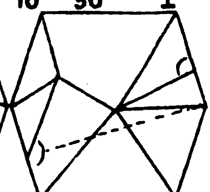
152

$10^{TT}{}_{49}$ $M_{\perp}$



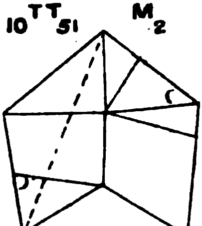
153

$10^{TT}{}_{50}$ $M_{\perp}$



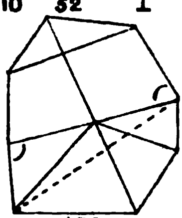
154

$10^{TT}{}_{51}$ M_{2}



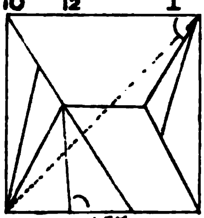
155

$10^{TT}{}_{52}$ $M_{\perp}$



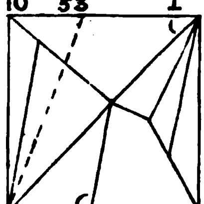
156

$10^{TB}{}_{12}$ $M_{\perp}$



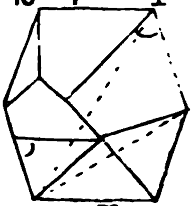
157

$10^{TT}{}_{53}$ $M_{\perp}$



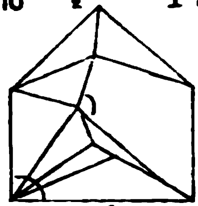
158

10^{TW_1} $M_\perp$



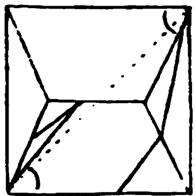
159

$10^{W(W)_2}$ $M_\perp$



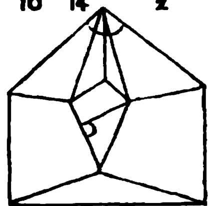
160

$10^{TB_{13}}$ $M_\perp$



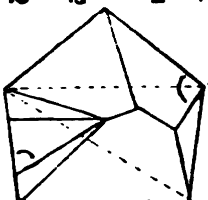
161

$10^{TB_{14}}$ M_2



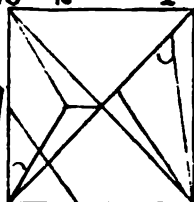
162

$10^{TB_{15}}$ $M_\perp$



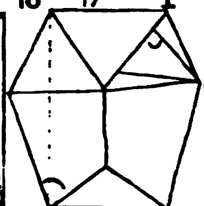
163

$10^{TB_{16}}$ $M_\perp$



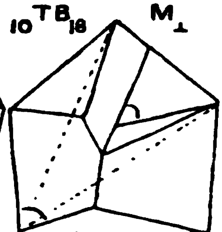
164

$10^{TB_{17}}$ $M_\perp$



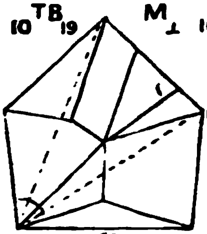
165

$10^{TB_{18}}$ $M_\perp$



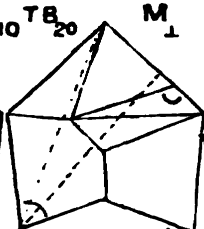
166

$10^{TB_{19}}$ $M_\perp$



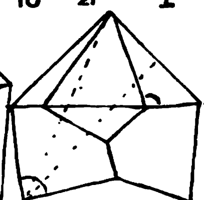
167

$10^{TB_{20}}$ $M_\perp$



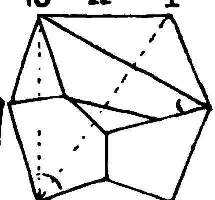
168

$10^{TB_{21}}$ $M_\perp$



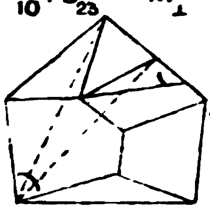
169

$10^{TB_{22}}$ $M_\perp$



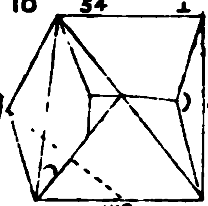
170

$10^{TB_{23}}$ $M_\perp$



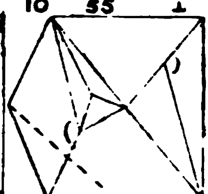
171

$10^{TT_{54}}$ $M_\perp$



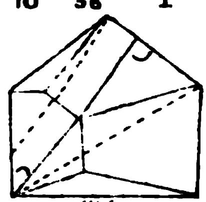
172

$10^{TT_{55}}$ $M_\perp$



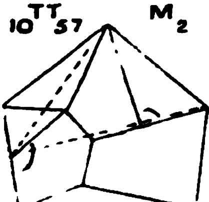
173

$10^{TT_{56}}$ $M_\perp$



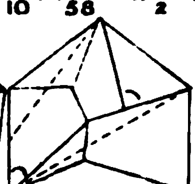
174

$10^{TT_{57}}$ M_2



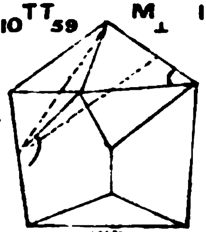
175

$10^{TT_{58}}$ M_2



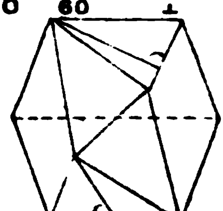
176

$10^{TT_{59}}$ $M_\perp$

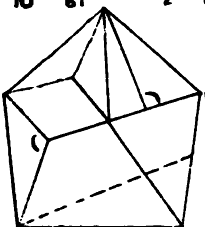


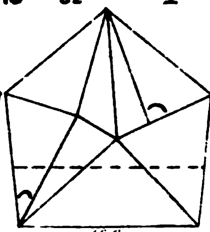
177

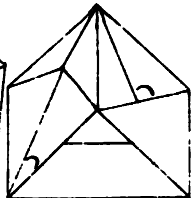
$10^{TT_{60}}$ $M_\perp$

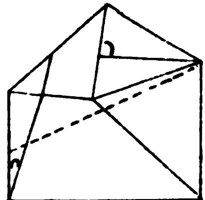


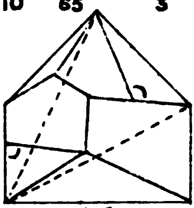
178

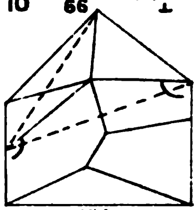
10^{TT}_{61} M_2

179

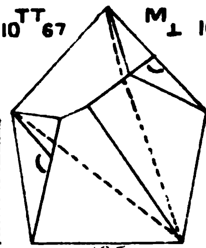
10^{TT}_{62} $M_\perp$

180

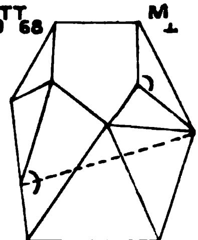
10^{TT}_{63} $M_\perp$

181

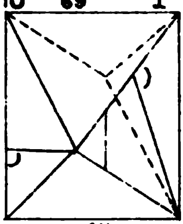
10^{TT}_{64} $M_\perp$

182

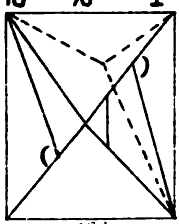
10^{TT}_{65} M_3

183

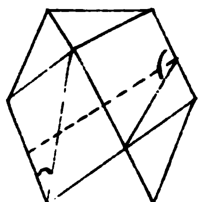
10^{TT}_{66} $M_\perp$

184

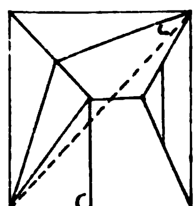
10^{TT}_{67} $M_\perp$

185

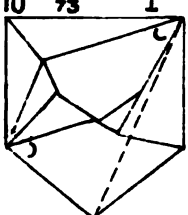
10^{TT}_{68} $M_\perp$

186

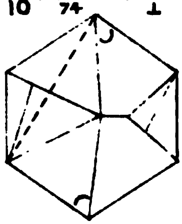
10^{TT}_{69} $M_\perp$

187

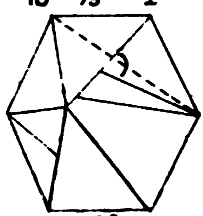
10^{TT}_{70} $M_\perp$

188

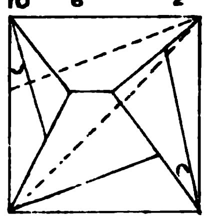
10^{TT}_{71} $M_\perp$

189

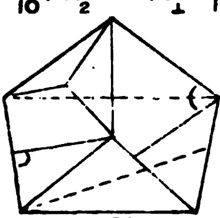
10^{TT}_{72} $M_\perp$

190

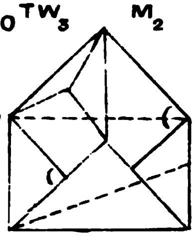
10^{TT}_{73} $M_\perp$

191

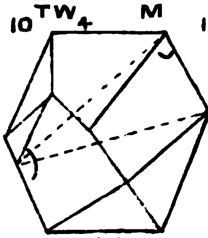
10^{TT}_{74} $M_\perp$

192

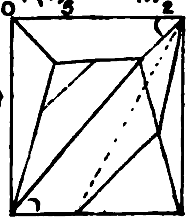
10^{TT}_{75} $M_\perp$

193

10^{BB}_{6} M_2

194

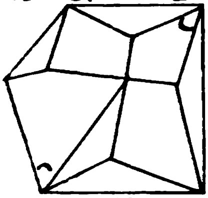
10^{TW}_{2} $M_\perp$

195

10^{TW}_{3} M_2

196

10^{TW}_{4} M

197

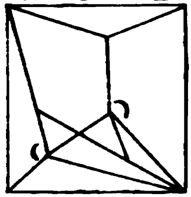
$10^{T(T)}_{5}$ M_2

198

$10^{\mathrm{TB}}{}_{24}$ $M_{\perp}$



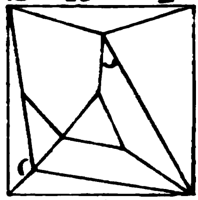
199

$10^{\mathrm{TB}}{}_{25}$ $M_{\perp}$



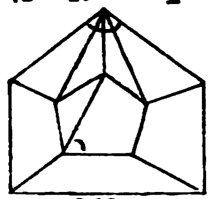
200

$10^{\mathrm{TB}}{}_{26}$ $M_{\perp}$



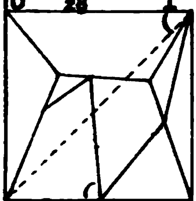
201

$10^{\mathrm{TB}}{}_{27}$ $M_{\perp}$



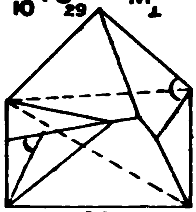
202

$10^{\mathrm{TB}}{}_{28}$ $M_{\perp}$



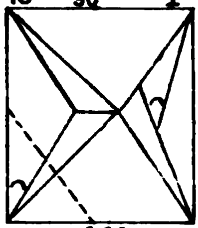
203

$10^{\mathrm{TB}}{}_{29}$ $M_{\perp}$



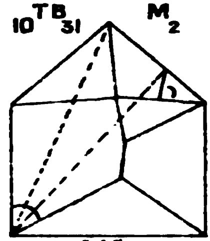
204

$10^{\mathrm{TB}}{}_{30}$ $M_{\perp}$



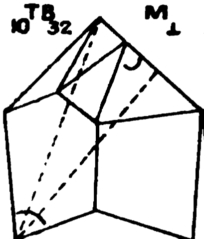
205

$10^{\mathrm{TB}}{}_{31}$ M_{2}



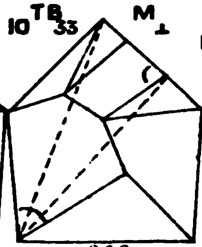
206

$10^{\mathrm{TB}}{}_{32}$ $M_{\perp}$



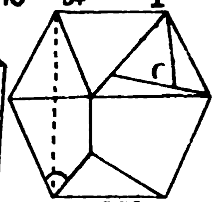
207

$10^{\mathrm{TB}}{}_{33}$ $M_{\perp}$



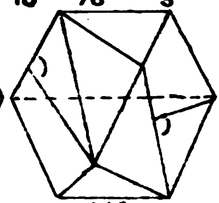
208

$10^{\mathrm{TB}}{}_{34}$ $M_{\perp}$



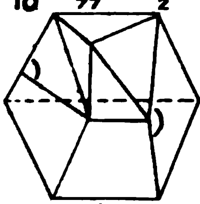
209

$10^{\mathrm{TT}}{}_{76}$ M_{3}



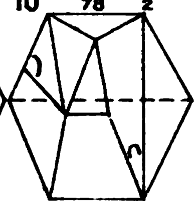
210

$10^{\mathrm{TT}}{}_{77}$ M_{2}



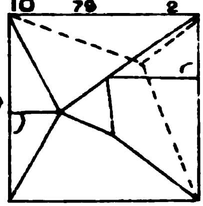
211

$10^{\mathrm{TT}}{}_{78}$ M_{2}



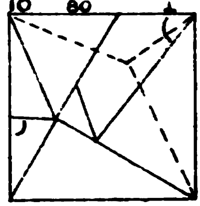
212

$10^{\mathrm{TT}}{}_{79}$ M_{2}



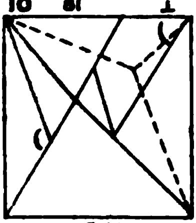
213

$10^{\mathrm{TT}}{}_{80}$ $M_{\perp}$



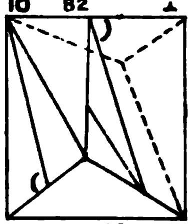
214

$10^{\mathrm{TT}}{}_{81}$ $M_{\perp}$



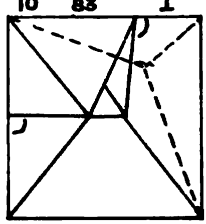
215

$10^{\mathrm{TT}}{}_{82}$ $M_{\perp}$



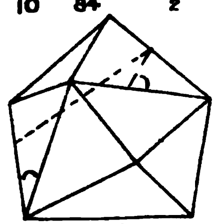
216

$10^{\mathrm{TT}}{}_{83}$ $M_{\perp}$



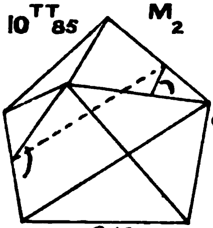
217

$10^{\mathrm{TT}}{}_{84}$ M_{2}



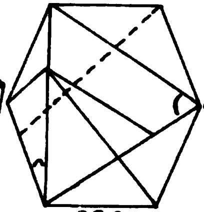
218

10^{TT}_{85} M_2



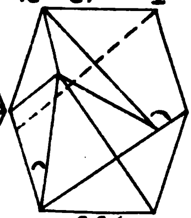
219

10^{TT}_{86} $M_\perp$



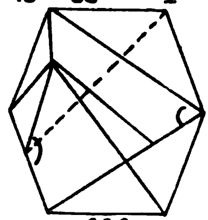
220

10^{TT}_{87} $M_\perp$



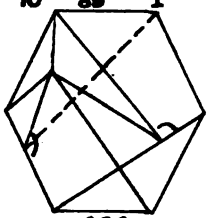
221

10^{TT}_{88} $M_\perp$



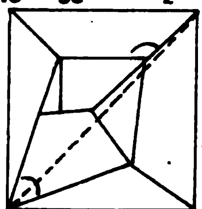
222

10^{TT}_{89} $M_\perp$



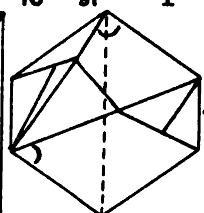
223

10^{TT}_{90} M_2



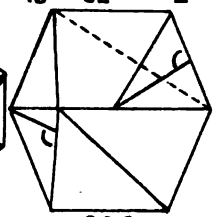
224

10^{TT}_{91} $M_\perp$



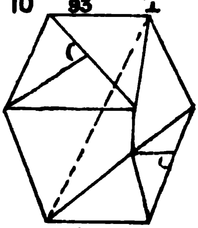
225

10^{TT}_{92} $M_\perp$



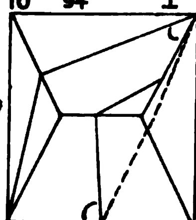
226

10^{TT}_{93} $M_\perp$



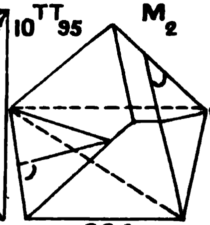
227

10^{TT}_{94} $M_\perp$



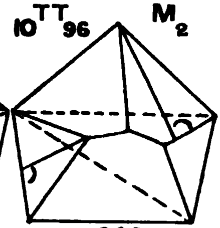
228

10^{TT}_{95} M_2



229

10^{TT}_{96} M_2



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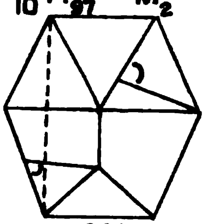
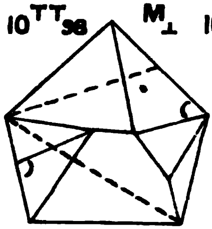
10^{TT}_{97} M_2



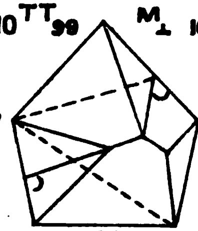
231

10^{TT}_{98} $M_\perp$



232

10^{TT}_{99} $M_\perp$



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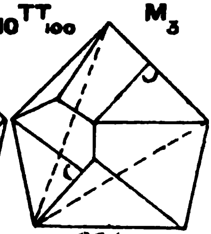
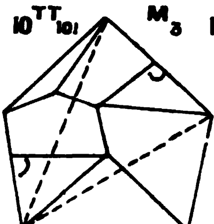
10^{TT}_{100} M_3



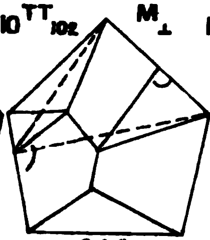
234

10^{TT}_{101} M_3



235

10^{TT}_{102} $M_\perp$



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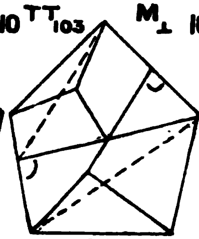
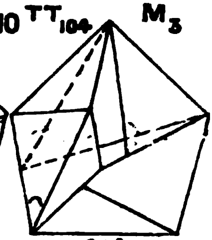
10^{TT}_{103} $M_\perp$



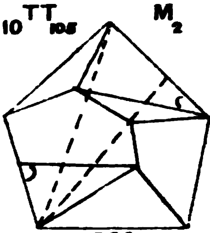
237

10^{TT}_{104} M_3



238

$10^{TT}{}_{105}$ M_2



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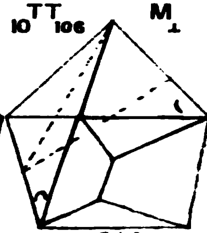
$10^{TT}{}_{106}$ $M_\perp$



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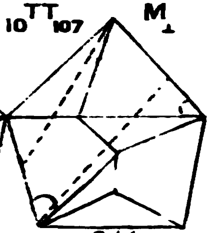

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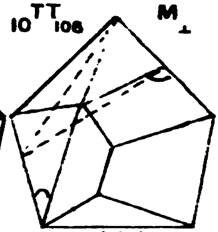
$10^{TT}{}_{108}$ $M_\perp$



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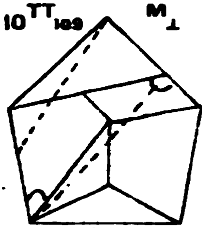
$10^{TT}{}_{109}$ $M_\perp$



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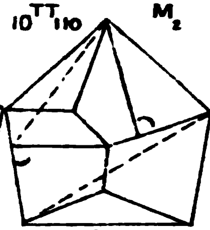

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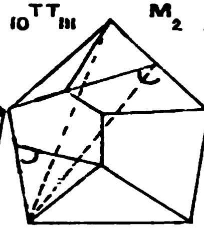

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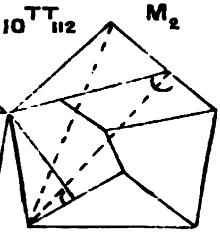
$10^{TT}{}_{112}$ M_2



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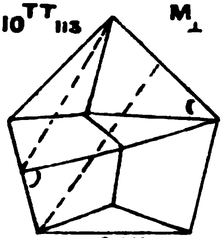
$10^{TT}{}_{113}$ $M_\perp$



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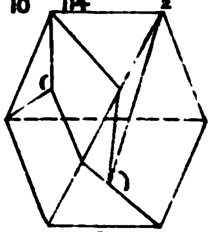
$10^{TT}{}_{114}$ M_2



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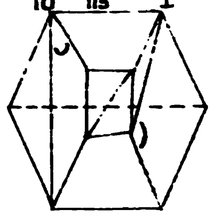
$10^{TT}{}_{115}$ $M_\perp$



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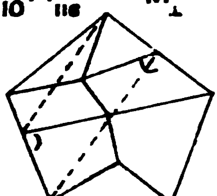
$10^{TT}{}_{116}$ $M_\perp$



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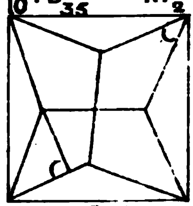
$10^{TB}{}_{35}$ M_2



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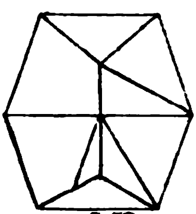

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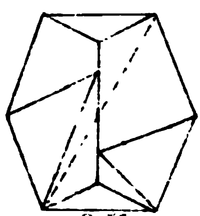


253

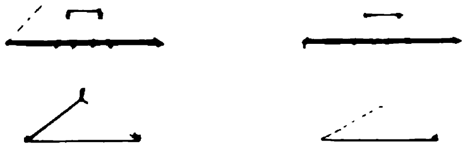
CORRIGENDA IN THE PAPERS ON POLYEDRA IN VOL. XXXII.

Page 178, line 9, for 4^{4e}, read 4^{4ad}.
 „ 179, line 8, *ab inf.*, for 3358, read 3355.
 „ 185, line 20, for $M_1' M_2'$, read $M_1^{-1} M_2^{-1}$.
 „ 189, line 10, for 4, read 4^{di}.
 „ 191, line 10, *ab inf.*, for 60 read 6.
 „ 196, line 8, *ab inf.*, for 9-acron, read 8-edron.
 „ 199, line 8, *ab inf.*, for AB, read (A–1) (B–1).
 „ 229, line 2, *ab inf.*, for 76 read 77; and make all the f's capitals, and for K put k.

CORRIGENDA IN THE PLATES OF POLYHEDRA IN VOL. XXXII.

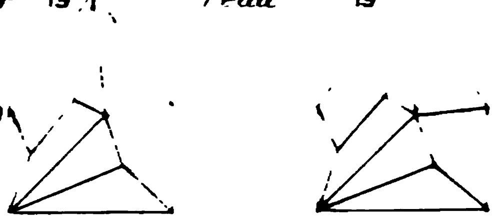
for M^{1}_{1} *read* M^{1}_{1}

Page 203



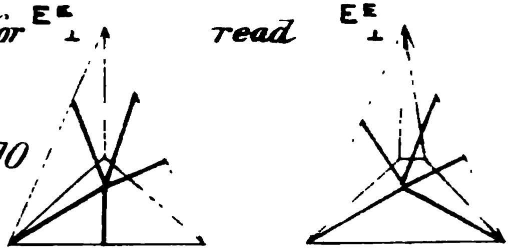
for E^{D}_{13} *read* E^{D}_{13}

Page 209



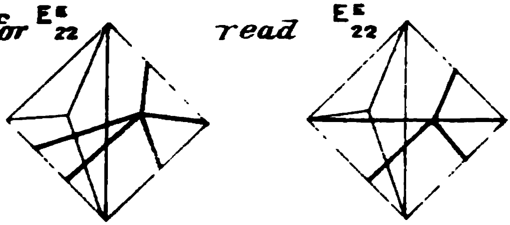
for E^{E}_{1} *read* E^{E}_{1}

Page 210



for E^{E}_{22} *read* E^{E}_{22}

Page 211



CHANGE OF CLIMATE—SECULAR, AND CAUSED BY HUMAN AGENCY.

By RICHMOND LEIGH, M.R.C.S.

The climate of the earth is not immutable—at least, when considered in limited localities—but has experienced many and varied changes. Taken in its entirety, no climatic change *may* have occurred at any period; there *may* have always been the same average mean temperature, the same amount of evaporation and of condensation, as rain, snow, etc., as well as the same relative succession of the seasons.

Indeed, it is difficult to conceive, except on one theory, of any cause of change from without, except to such slight extent as might be accounted for by the attraction of aerolites and similar bodies, or by eccentricity of the earth's orbit. This latter cause might produce some considerable alteration of climate, but, from its nature, it would tend to self-rectification.

There is one particular theory that presumes, and, if correct, that would account for great alteration in climate, viz., that of the secular cooling of the earth. But geological research has tended to reduce the probability of this theory to a minimum, and it has been, in consequence, almost discarded.

It would be a most interesting and valuable point to discover whether the mean temperature of the whole globe varies or not, but the facts available at the present time for such an inquiry are greatly insufficient for such a purpose.

Whether the sum total of the earth's climate be changed or not, its distribution is very greatly altered.

The causes which have contributed to this alteration are either general or local.

The general causes are those which act on the globe as a whole, and which, consequently, affect to a greater or lesser extent the entire surface of the earth. They have left many traces of their action in prehistoric times, and many theories have been invented to explain this action.

Different mathematicians who have of late gone into the question of a change in the geographical position of the earth's axis of rotation, agree in its theoretical possibility by redistribution of its superficial matter; but they do not agree on the amount of such change. Sir W. Thomson has asserted, as highly probable, that the poles may, in ancient times, have been very far from their present position, and may have gradually moved through ten, twenty, forty, or more degrees, without the occurrence at any time of any perceptible sudden disturbance of land or water.

Croll considers the chief cause of secular change of temperature to be the deflection of ocean currents by alterations in their beds. It is thus that he considers the gulf stream to have been produced, which he assumes to have changed the climate of England from its antecedent glacial character.

There is, at the present time, an unequal distribution of temperature in the two hemispheres of the earth, north and south, the north being much the warmest, to account for which various explanations have been offered, besides those already adduced. But whatever other causes may have assisted to produce this result, a more direct one appears in the fact that the summer period of the northern hemisphere actually exceeds that of the south by seven or eight days, or about one hundred and seventy-eight hours. This is owing to the unequal speed of the earth in different parts of its orbit.

The hours of daylight in the north also exceed the hours of night, in consequence of the longer time the Arctic pole is inclined to the sun. A very gradual change, however, is

in constant action, through the precession of the equinoxes, which will in due time equalise the mean temperature of both hemispheres.

The March equinox is every year twenty minutes before the last. Therefore, in twelve thousand nine hundred years the conditions of the two hemispheres will be changed, and the south will be the warmest.

These general causes of climatic change are beyond the range of human influence, and can but be viewed as a part of the general cosmic economy. The local changes, on the contrary, are nearly all the direct result of human action, and as such of great practical importance to mankind.

When civilised man first appeared, the surface of the earth, with few exceptions, was most probably covered with forest.

The two Americas were so clothed at their discovery, and we may reasonably infer that other portions of the globe were in like condition. This forest-clad state is evidently the normal and natural one; for when land is abandoned after cultivation—the climate remaining suitable for forest growth —and being, at the same time, free from browsing animals, it almost invariably returns to that primitive condition.

In all probability, for a considerable space of time, the earth's surface and local climate underwent slight alteration. But it is evident that at an early period a partial denudation of forest, and deterioration of soil, produced a corresponding unfruitfulness; and that the lesson learnt so recently and dearly, of the folly of disturbing nature without equivalent counteraction, was learnt previously by the ancients. The existence of works of irrigation, canals and reservoirs, indicate a deficient natural supply of water, or rainfall, when they were constructed; and since their decay, the lands they fertilised have sunk into either partial or complete sterility.

There are numerous facts which can only be understood

by considering that the climatic conditions of certain countries, in the earlier historical times, were very different to their present states. In many places where, at the present time, a scattered people obtain a bare subsistence, in former times a dense population lived luxuriously. Syria, Persia, Northern Africa, and many other countries, present notable instances of fertility, and consequent great habitability, within the earlier historical period. The Roman Empire also, throughout a very great portion of its extent, was endowed with a much greater fertility than it has now, according to the accounts of the old historians.

Marsh * concludes that "more than half their extent—not excluding the provinces most celebrated for the profusion and variety of their spontaneous and cultivated products, and for the wealth and social advancement of their inhabitants—is either deserted by civilised man, and surrendered to hopeless desolation, or, at least, greatly reduced in both productiveness and population. Vast forests have disappeared, the vegetable earth accumulated beneath the trees, by the decay of leaves and fallen trunks, is washed away; meadows, once fertilised by irrigation, are unproductive, because the cisterns, reservoirs, and canals are broken or destroyed; rivers have shrunk to rivulets, and rivulets become the mere outflows of the rainy season, and other scarcely less important changes in the physical condition of the inhabited earth have taken place."

The regions thus affected include Persia, Syria, Mesopotamia, Armenia, much of Asia Minor, Arabia in great part, Northern Africa, Greece, and parts of even Italy, Spain, and Sicily, etc.

This decadence of highly-developed countries forms a most interesting and instructive study, which is well illus-

* An able American author, upon whose work, *The Earth as Modified by Human Action*, I have largely drawn.

trated in Mr. Mott's Presidential Address to this Society in 1873. In selecting the ruins found in Easter Island for his text, and taking a small unconnected part of the earth's surface, he limited, as far as possible, the external surrounding causes of change, and from it drew most important and philosophical deductions. Such a limited study being of so much value, what undeveloped evidence does the enormous ruins in other and continental parts of the earth possess?

Considering merely, as at present, those constructed for purposes of water-supply and of irrigation only, they are far beyond any works in operation at the present time. Those constructed by the Romans are, at least many of them, well known. By these they transformed large arid and sandy regions into tracts of great fertility; fertility which disappeared with the neglect or ruin of the works, and which now present their former aridity, as in Algeria.

In these branches of knowledge and art there would seem to have been a great falling off till the recent revival. An example of the application of forgotten knowledge is found in the strict laws enacted by the Emperor Constantine for the protection of the forest of Belgrade. In this forest arose the springs that fed the magnificent series of aqueducts and cisterns which still supply Constantinople with water.

The magnitude of the works constructed by the ancients is shown by the fact that, in fourteen districts of the presidency of Madras, not less than forty-three thousand reservoirs, constructed in former ages for irrigation purposes, are now in use, beside at least ten thousand more which are in ruin.

* * * *

Nature, when undisturbed, shows little alteration in condition or climate. The renovating and reproductive power possessed by her endues her with an indefinite

permanence, the only change presented by her being in the increase of her domain. The forces at present operating in nature tend to increase the reign of animated nature, so long as undisturbed by human action.

But the appearance of man in a state of civilisation exercises a most decided and remarkable change. He is the *primum mobile* of the local causes of change of climate. By cutting down forests, draining lakes and marshes, introducing alien plants and animals, extirpating those which are indigenous, and by many other means, he disturbs the harmony of nature. His is the only power which can, not only oppose, but, defeat the efforts of nature, and, as Marsh remarks, this would seem to show that, though in her domain, he is not really of her.

Man disturbs the proportions and accommodation which insured the stability of existing conditions, and, of all organic beings, is alone to be regarded as essentially a destructive power. Purely untutored humanity, it is true, interferes comparatively little with the arrangements of nature, but the destructive agency of man increases as he advances in civilisation. Exhausting the land for his means of support, without granting it agencies by which to renew its fertility, he causes, as Schleiden remarks, "a broad band of waste land to follow gradually in the steps of cultivation."

There are many countries, previously enumerated, which, within the brief space of time, "the historical period," were covered with luxuriant woods, verdant pastures, and fertile meadows, where the operation of causes set in action by man has brought the earth to a desolation almost as complete as that of the moon. "The earth is fast becoming an unfit home for its noblest inhabitant, and another era of equal human crime and human improvidence, and of like duration with that through which traces of that crime and of that improvidence extend, would reduce it to such a condition of impoverished

productiveness, of shattered surface, of climatic excess, as to threaten the depravation, barbarism, and even extinction of the species." (Marsh, *op. cit.*)

There is, certainly, a partial reverse of this picture in the attempts at restoring the balance of nature which have especially been made in the last half-century, but these are little when compared with the destruction that has been perpetrated.

The action by which man has produced the greatest change in the course of nature is the cutting down of forests, thus depriving portions of the earth of their natural covering. Other, but less important, changes have been produced by the draining of marshes and lakes, by embankments of rivers, canal construction, land-drainage, diversion of rivers, and other and less important actions.

Dearborisation, or the removal of woods and forests, has been followed by results disastrous and immense, chief of which are, the washing away of soil, diminished rainfall, floods, production of marshes, increase of storms, and greater variation in temperature.

The first and most direct effect of removal of forests and woods is, that the soil being exposed and not fixed by the roots of the trees, it is wasted away by the heavier falls of rain or by floods. Sixteen years ago it was calculated that four-tenths of the Ligurian provinces, in Italy, had been washed away or rendered incapable of cultivation in consequence of the felling of the woods. In France, in Dauphiny and Provence, the destruction of trees, though actually increasing arable land at first, has caused the formation of mountain torrents, and left the earth exposed to wind and storm, so that much more has been swept away than has been gained, and consequently large tracts are deserted that were before well-peopled.

Referring to one of these districts, Young, writing in

1789, says:—"About Barcelonette, and in the highest parts of the mountains, the hill-pastures feed a million of sheep, besides large herds of cattle; the valleys I have visited are in general beautiful." Of another—the valley of Embrun—Hericart de Thury said, in 1806:—"In this magnificent valley nature has been prodigal of her gifts. Its inhabitants have blindly revelled in her favours, and fallen asleep in the midst of her profusion."

A little later, in 1843, Blanqui, the eminent political economist, in a paper read before the Academy of Moral and Political Sciences (of France), states:—"The clear, brilliant Alpine sky of Embrun, Barcelonette, Gap, and of Digne, produces droughts, interrupted only by diluvial rains, like those of the tropics. The abuse of the right of pasturage and the felling of the woods have stripped the soil, and the scorching sun bakes it to the consistence of porphyry. When moistened by the rain, as it has neither support nor cohesion, it rolls down to the valleys, sometimes in floods resembling black, yellow, or reddish lava, sometimes in streams of pebbles, and even huge blocks of stone, which pour down with a frightful roar. In these districts there is no time to lose. In fifty years France will be separated from Savoy, as Egypt from Syria, by a desert."

Ten years later, M. De Bonville, Prefect of the Lower Alps, addressed to the French Government a report, in which the following passages occur:—"Our Alps are wholly, or in large proportion, bared of wood. Their soil—scorched by the sun of Provence, cut up by the hoofs of the sheep, which, not finding on the surface the grass they require for their sustenance, gnaw and scratch the ground in search of roots to satisfy their hunger—is periodically washed away and carried off by melting snows and summer storms. In places where ten years ago there was still cultivated ground to be seen, there is now but a vast torrent. The population

has, as a consequence, diminished no less than five thousand in the five years previous to 1851. Unless prompt measures are taken, it is easy to fix the epoch when the French Alps will be but a desert. The population will further decrease."

Commenting on this, Marsh says:—"Time has verified the prediction of De Bonville; the later census returns show a progressive diminution in the population of the departments of the Lower Alps, the Isére, Upper and Lower Pyrenees, Ardennes, Vosges, etc.; in short, in all the provinces formerly remarkable for their forests. This diminution is not the result of emigration; it is simply a transfer of population from soils which human folly has rendered uninhabitable."

Another striking instance is that of the sandhills of the Frische Nehrung, on the coast of Prussia, which were formerly wooded down to the water's edge, and it was only in the last century that, in consequence of the destruction of their forests, they became moving sands. King Frederick William I. was once in want of money. A certain Herr von Korff promised to procure it for him, if he could be allowed to remove something *quite useless*, viz., the forests of this and other districts of Prussia. It was done; the king had 200,000 thalers, but the State received enormous injury. The sea winds rush over the bared hills, the Frische Haff is nearly choked with sand, the channel between Elbing, the sea, and Konigsberg endangered, and the fisheries in the Haff injured. The State would willingly now expend millions to restore the forest again.

The most important function of forests, as shown in reverse on their removal, is that of equalising the distribution of moisture on the land. When the forest is gone, the great reservoir of moisture stored up in its vegetable mould is evaporated, and returns only in deluges of rain that wash away the parched dust into which that mould has been con-

verted. The wooded hills become ridges of bare rock, from which the dried soil is washed, choking the watercourses and causing alternate floods and droughts. "The whole earth, unless rescued by human art from the physical degradation to which it tends, becomes an assemblage of bald mountains, of barren turfless hills, and of swampy malarious plains." (Marsh.)

It sems sufficiently proved that dearborisation causes the disappearance of springs, the diminution in permanent volume of rivers, and a lowering of level of lakes. After a district of country has been completely, or even partly, cleared of its forest growth and brought under cultivation, the drying of the soil, under ordinary conditions, goes on for generations, perhaps for ages. In many parts of New England there are tracts of land, many square miles in extent, which were partially cleared sixty or seventy years ago, and where little or no change in proportion of cultivated ground, pasturage, and woodland has since taken place, in which the ground is drying slowly, yet steadily. Springs are disappearing and the rivulets diminishing in volume.

The effect of dearborisation on rivers is well illustrated by its effects in Russia, where, according to Hohenstein, who was long employed as a forester by the Government, the consequences of the general war upon the woods in that country was already, some years back, most disastrous, through the river Volga being thereby diminished in volume. This river, the great highway of Russian commerce, is much lessened in volume, and is, in fact, rapidly drying up, while the great Muscovite plains are fast advancing to an Arabian sterility.

The removal of the forest causes a diminution in the rainfall, and a consequent infertility of the land. This infertility does not, however, proceed simply from the lesser fall

of rain, but largely from the failure of unwooded land to store up the moisture, as in a reservoir, for future use.

Examples of this result are abundant, and many of them well known, as at St. Helena, the Cape de Verd Islands, Mauritius, Barbadoes, etc. The woods of Spain and Portugal were cut down long ago, being supposed by the natives "to breed birds, and birds eat up the grain," and have been followed by dryness and sterility.

There are parts of South Africa, at present arid and sterile, in which, according to the natives, there were formerly large rivers in which hippopotami abounded. Livingstone and Moffat also saw remains of immense trees of *acacia giraffæ*, etc. Many of the tribes in those regions have wantonly destroyed trees, especially the Bechuanas, who are a nation of levellers of timber.

Rivers fed by springs and shaded by woods are comparatively uniform in volume, temperature, and chemical composition; to which may be added, matter in suspension. Senator Torelli (of Italy) calculated that four-fifths of the precipitation in heavy rains on forest land are absorbed by the soil or otherwise detained, only one-fifth being delivered to the rivers rapidly enough to cause danger of flood; while in open ground the proportions are reversed. The probability of flood is but slight in rivers draining wooded districts, and their banks are little abraded or their channels obstructed by earth, gravel, or other obstacles. Their beds are only subject to slow and gradual changes, and they carry down to the sea little silt or sand, which, in torrential streams, raises their beds and causes them to form marshes near their outlet.

As an example of this, the Seine, in the fourth century, was almost wholly exempt from inundations, and flowed with a uniform current through the whole year, whereas now its level varies thirty feet at different periods. A more striking

result is seen in the Combe d'Yeuse, in the department of Vaucluse, in France, which became subject to the most violent torrential floods after the destruction of the woods of its basin between 1828 and 1838, but has now been completely subdued and its waters brought to a peaceful flow by replanting its valley. About an hour from Thusis, on the Splügen road, opens the awful chasm of the Molla, which, a hundred years ago, poured its peaceful waters through smiling meadows, protected by the wooded slopes of the mountains. But the woods were cut down, and with them departed the rich pastures, which are now covered with piles of rock and rubbish, swept down from the mountains.

The river Mella (Italy) was till recently an even-flowing river, noticed even by Catullus as flowing "*molli flumine.*" In the higher part of its basin are some ironworks, which have for a considerable time created a demand for wood, to supply which the forests have gradually been cut down. The result has been that, whereas before 1850 no destructive inundation was on record, in that year a great flood occurred, which destroyed many bridges, factories, and other buildings; and, what was a far more serious evil, swept off the rocks an incredible amount of soil, converting one of the most fertile valleys of the Italian Alps into a bare and barren ravine.

The water-regulating uses of trees are also seen in marshy localities. Their roots act mechanically as conductors of the superfluous humidity of the superficial earth to lower strata; they often penetrate subsoil almost impervious to water, and drain the water which would otherwise remain and form a bog. This was illustrated in the district of La Brenne, in France, a tract of two hundred thousand acres, below which, at a slight depth, is an argillaceous subsoil, impermeable to water. Ten centuries ago this was covered with woods and fertile and salubrious meadows, while since the destruction of these woods it has become a

malarious region of pools and marshes. In Sologne, the same cause has withdrawn a million of acres of ground from cultivation which were once well-wooded and productive.

Beyond their water-regulating use, trees would seem to have, in common with some other plants, a direct beneficial effect upon miasmata. According to Marsh, the great swamps of Virginia and the Carolinas are healthy, even to the white man, so long as the forests in and around them remain, but become very insalubrious when the woods are felled. Rigaud de Lille observed localities in Italy where the interposition of a screen of trees preserved the places beyond it from the miasmata on its other side. A few rows of sunflowers, planted between the Washington Observatory and the marshy banks of the Potomac, saved the inmates of that institution from the intermittent fevers to which they had been liable, according to Maury.

It is evident that woods must protect the ground they cover to a great extent from wind. Becquerel found that in the valley of the Rhone, a simple hedge two metres in height was a sufficient protection from cold winds for a distance of twenty-two metres, that is, eleven times its height.

The mistral, or north-west wind, whose chilling blasts are so fatal to tender vegetation in the spring, is said to have appeared in Southern France (Ardeche) about the time of Julius Cæsar or Augustus, on the destruction of the forests, but it did not reach its full strength till towards the close of the sixteenth century. Since that time valuable crops have been banished by the rigour of the seasons, being unable to contend against the tempests, cold, and drought. Under the Consulate, the clearings had exerted so injurious an effect upon the climate that the cultivation of the olive had retreated several leagues, and since 1836 this branch of rural industry has been abandoned in a great number of localities where it was advantageously pursued before.

Beyond the protection of the land from winds, forests have a more important function in the moderating and diminishing of storms. The sirocco and other winds prevail much more at present, in many parts of Italy, than formerly. They injure harvests and vineyards, and sometimes ruin the crops of the season. In the Communes of Modena and Reggio—through the removal of the trees—where formerly straw roofs resisted the force of the winds, tiles are now hardly sufficient; in others, where tiles answered for a covering, large slabs of stone are now ineffectual; while in many neighbouring Communes the grapes and the grain are swept off by the blasts of the south and south-west winds.

The Karst, the high plateau to the north of Trieste, is now one of the most parched and barren districts in Europe, owing to the felling of its woods centuries ago to build the navies of Venice. The result is that, according to Hummel, "the miserable peasant of that region now sees nothing but bare rock swept and scoured by the raging *Bora*, the fury of which wind was formerly subdued by the mighty firs then existing."

In the Western States of America (U.S.), terrible cyclones and other wind-waves have become so frequent and destructive, that the maple orchards have been in a measure ruined over very large districts; and Marsh is of opinion that, in the near future, maple sugar-making will be over for ever.

Considerable alterations in the local temperature are produced by the removal of forests. They tend to equalise and regulate the distribution of both heat and cold, and to diminish their extremes. A well-marked increase in winter temperature is clearly demonstrated, and it is most probable that the summer heat is modified in a similar but inverse manner. This latter effect has not been considered to any notable extent, and proofs of its existence and amount are

wanting, but the altered winter temperature is sufficiently proved.

In Italy, France, and Switzerland, the spring is much retarded, and late frosts at that season have been more frequent within a recent period. This is in all probability due to the destruction of the forests, which formerly screened and protected the soil from cold winds. The same thing has been noted in Sweden, Asbjörnsen stating that, in many districts where the forests have been cleared off, the spring comes on a fortnight later than in the last century.

In the time of the great Napoleon, the ordinary amount of charcoal used for reducing iron did not suffice, owing to England not exporting any of the latter. Trees were cut down largely to supply the charcoal, with the effect, at Piazzatore, of altering the climate so that maize failed to ripen as before. The trees were replanted by an association formed with that object, and maize flourished again as formerly.

The orange, which formerly grew abundantly in the south of France, now flourishes only at a few sheltered points, and it is threatened even at Hyères; and in many localities north of the Alps fruit trees thrive no longer, and it is difficult to raise young plants.

The removal of forests appears to increase the frequency of hailstorms. In many parts of Italy and France they have become frequent and violent within the last half century or thereabouts, in places where they were nearly if not quite unknown previously. Among districts which have specially suffered from hailstorms, may be named the plains of Lombardy, the vicinity of Verona and Vicenza, and between the Riviera and Montferrat. To provide against this climatic change, joint-stock companies have been formed specially to insure against damage by hail, as well as by fire and lightning.

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Dearborisation has produced the chief change in local climate, and has been the most important effective human agency in bringing about this altered condition. But there are many other means by which man interferes with the operations of the laws of nature, generally to his great disadvantage. Of these, the next in importance, with regard to its results, is alteration of the water-level and distribution, whether by draining, canal-making, embankments of rivers, or otherwise. Taking a wide view of the subject, it would seem that nature is almost, if not absolutely, perfect in her constitution, and that any interference of man is sure to be followed by ill results, unless carefully provided against. The natural proportion of land, marsh, and water would seem to be the only true one, and any artificial disturbance of this proportion must be counterbalanced by art. So much is this the case that even the draining of marshes is of doubtful advantage. Babinet, from a large consideration of the subject, condemns it; and Marsh states that the draining of marshes, as all other methods of drying the superficial strata by ditches or drains, has the same effect as clearing the forest. The draining of land in this country has been considered such an unmixed good that it is desirable to inquire into the reasons for that opinion. The chief advantages claimed are, increased heat of the soil and greater resultant fertility. They are undoubtedly true, and, as Marsh says, "the immediate improvement of soil and climate, and the increased abundance of the harvests, have fully justified the eulogiums of the advocates of the English system of surface and subsoil drainage." To this is most probably due the elevation of temperature in England, amounting, according to Glaisher, to two degrees Fahrenheit in the last century, and also the diminished rainfall.

On the other hand, draining has the disadvantage of carrying off, in a few hours, water that would have percolated

through the earth for weeks or months, causing inundations at one time, while at another, the land is dried up, and the river becomes a rivulet. It would appear also to interfere with the rainfall, causing a slight diminution, as before stated.

District meteorological changes result from the draining of marshes, the most notable of which is that, after draining, the land is much less liable to depression of temperature. In temperate and cold climates, the neighbourhood of a marsh is especially liable to late spring and early autumnal frosts; but they cease to be feared after draining, and this is particularly observable in cold climates, as in Lapland. In summer, marshes are cooler than land, from the aqueous evaporation.

Many thousands of acres of land have been obtained through the draining of lakes, but the injury to the surrounding country is as great as, if not greater than, the advantage gained. The lowering and extinction of lakes diminish or dry up the springs in their neighbourhood; if the banks of the lake are steep, landslips frequently occur from the removal of the water-pressure, while other minor, less marked, results, climatic and physical, diminish the advantage gained to a doubtful minimum.

The embanking of rivers, with which may be considered the construction of canals, has not produced any great change in the climate or condition of their environment. The former is, however, the direct result of change elsewhere, which causes a too rapid discharge of the rainfall, or melted snow, from the bared hills where lie the river sources. This system of embanking rivers, with the object of preventing floods in heavy rains, has frequently the effect of gradually raising the bed of the river, until it is considerably above the surrounding plain. The Hoangho, for a great portion of its course in China, flows high above the surrounding country,

and threatens to break through its embankments, and to flood millions of acres of fertile land. It has already, in its lower course, repeatedly burst its dykes and changed its channel, debouching sometimes north and sometimes south of the peninsula of Shantung, thus varying a distance of two hundred and twenty miles.

On the river Po, there are certain towns within its embankments which were formerly secure from flood by the height of the artificial mounds on which they were built, but they have recently been obliged to construct ring-dykes for their protection. By the raising of the river bed disastrous floods occur occasionally through accidents to the embankments. In 1839, during a flood, a breach of the embankment of the river Po occurred at Bonizzo. The water poured through and inundated one hundred and sixteen thousand acres, or one hundred and eighty-one square miles of the plain, in the lower parts to the depth of from twenty to twenty-three feet. In May, 1872, a similar accident happened near Ferrara, and one hundred and seventy thousand acres were overflowed, and thirty thousand persons driven from their homes. In October, in the same year, a breach occurred at Revere; two hundred and fifty thousand acres were inundated, and sixty thousand persons were forced to leave their habitations.

The extent of many of these river dykes is enormous, the largest being those of the Mississippi and tributaries, which have a total length of more than two thousand five hundred miles. These being comparatively new and unconsolidated, frequently give way to the ceaseless action of the river.

*   *   *   *   *   *

The changes already considered have, with one or two exceptions, been very disastrous to human industry; but the obtaining more definite knowledge regarding the operations

of nature, and the acting upon that information, has, to a considerable extent, recovered the land lost to husbandry.

The desolate state of the Karst, already mentioned, has been improved by the energetic efforts of the Austrian Government, upwards of four hundred thousand trees having been planted in the year 1866 alone, besides large quantities of seeds being sown.

In France, within the last few years, the healthfulness of the Sologne, which was a pestilential marsh, has been restored by forest plantations. A notably successful result of rightly applied forestry, though not of very recent date, is seen in the forest of Fontainebleau. This forest, which covers over forty thousand acres, grows over a soil composed almost wholly of sand, interspersed with ledges of rock. The sand forms not less than ninety-eight per cent. of the earth, and as it is almost without water, there would be but a drifting desert, but for the artificial propagation of trees upon it.

In Italy, the province of Brescia, and a part of that of Bergamo, which formerly were exposed to enormous injury after heavy rain, in a great degree escaped damage in the terrible inundation of October, 1872, and their immunity is ascribed to the improvements executed in the former province, in the Val Camonica, and in the upper basins of the other rivers which drain that territory. In all probability the artificially-watered fertile soil of Italy will be doubled, and that of France quadrupled, in the present century.

The land on the side of the Schelde, opposite Antwerp, presents the appearance of a forest when seen from an elevation in the position of that city. On entering the forest, it is seen to be but a series of regular rows of trees, the oldest of which is not forty years of age. The effect of this open plantation has been to moderate the severity of a climate which doomed the soil to sterility. Protected from wind, and

the sudden and great changes caused by it, the sands, formerly more barren than the plateau of La Hague, have been transformed into fertile fields.

In St. Helena, the result of the replanting of trees, recently carried out, has been that the rainfall has increased, so that it is now double what it was in the time of Napoleon.

In the United States of America, according to the report of the Department of Agriculture for February, 1872, it would appear that the recently-formed plantations in the Western States have already affected the water distribution of that region, and it is alleged that extinct rivers, whose beds have not been known to contain water since the settlement of the country, have begun to flow in consequence.

In Australia, Dr. Müller, director of the Botanic Gardens at Melbourne, has distributed through the country millions of seedling trees from his nurseries. Under the young growing wood small rivulets are soon formed; the results are superb, and the observation of every successive year confirms them. Forests and watercourses have thus been created at more than a hundred different localities.*

Among other beneficial results of reboissement is the removal of malaria. In many parts of Algeria this important change has resulted from the extensive plantations of *Eucalyptus globulus*—which is especially valuable on account of its rapid growth—which have been made.

The most important ameliorating changes of climate and soil have thus been effected by scientific forestry; but they are not the only improvements resulting from an observant and practical study of nature.

A most brilliant result of the application of such study, restoring the disturbed autonomy of nature, offers itself in the Val di Chiana and the Tuscan Maremme. These marshy,

* Marquis de Beauvoir in his "*Voyage Autour du Monde.*"

insalubrious, and sterile districts of a former period, have been rendered fertile and salubrious by works reflecting the highest credit on their successful inventors and undertakers. The chief object in view was to regulate the flow of the surface waters into and through it, as to cause them to deposit their suspended matter, and thereby to elevate the land above the water level. In the Maremme, besides, the salt water was prevented from mixing with the fresh and producing a malarious compound. The result has been that these formerly pestilent and infertile regions have not only been rendered productive, but restored to such a state of salubrity, that Viareggio, the chief town, is frequented now for its sanitary advantages, as it was formerly shunned from its miasmata.

* * * * *

The preceding are a few instances, out of many, of the benefit resulting from action based on an intelligent study of nature. Man is slow to learn the lesson of using but not abusing her bounties; and it is only the severe teaching of experience that has at length led him to see the folly of disturbing the economy of nature without counterbalancing works of restoration.

In Great Britain there have not been the terrible results witnessed elsewhere, but we nevertheless suffer great damage from floods, which are partly, if not wholly, preventible. But though the evil results of disturbing the balance of nature have not been felt in this country, they have affected more than one of the imperial colonies severely. In South Africa serious results have followed the careless removal of trees, to restore the balance of which upset Dr. Brown has laboured long and arduously. The drought and consequent famine in India is a well-known example of faulty agricultural economy.

Other instances might be quoted, but enough has been

stated to show the evil of interfering with the unerring hand of nature.

Let it be man's aim to seek after a more perfect knowledge of her economy, that the great and unique power which he possesses of marring or of furthering her efforts may be used for his benefit and not to his destruction.

xcept

Authorised Version.	Greek.	Vulgate: Hexaglot.	Vulgate: Folio, Nurembe[rg] A.D. 1479.	Bish
"God did tempt Abraham." Gen. xxii. 1.	ἐπείρασε (*Septuagint*)	tentavit	optavit	mpt
"Was led up—to be tempted." Matt. iv. 1.	πειρασθῆναι	ut temtaretur	ut tēptaretur	mpte
"The tempter." Matt. iv. 3.	ὁ πειράζων	temtator	tēptator	mpte
"A pinnacle." Matt. iv. 5.	το πτερύγιον	supra pinnaculum	supra pinnalum	pinac
"A lawyer-tempting him." Matt. xxii. 35.	πειράζων	temtans eum	temtās eū	mptii
"Master." Matt. xxii. 36.	Διδάσκᾶλε	Magister	Magister	aster
"A lawyer–tempted him." Luke x. 25.	ἐκπειράζων	temtans eum	tēptās illū	mpte
"Master." Luke x. 25.	Διδάσκᾶλε	Magister	Magister	aster
"This he said to prove him." John vi. 6.	πειράζων	temtans eum	temptans eu	ove
"Abraham, when he was tried." Heb. xi. 17.	πειραζόμενος	cum temtaretur	cū tēptaret :	ien p
"Rabbi" (which interpreted, is Master). John i. 39.	Ῥαββι-Διδάσκᾶλε	Rabbi–Magister	Rabbi–Magis	bbi–
"Thou art a teacher." John iii. 2.	Διδάσκᾶλος	Venisti Magister	Magister	ache
"Art thou a Master?" John iii. 10.	Σὺ εἶ ὁ διδάσκᾶλος	tu es Magister	tu es Magist	aster

* It is desirable not to talk about the *Russian* version. The version us... om t...
as old as that. Its language is consequently now quite antiquate... no d...
† The Russian has no definite article, but if it had been intended to de...

ON THE TRANSLATION OF Διδάσκᾶλος, πειράω, πειράζω, AND το πτερύγιον, IN THE AUTHORISED VERSION OF THE NEW TESTAMENT.

By J. BIRKBECK NEVINS, M.D., Lond.

The words which I desire to bring before your consideration are Διδάσκᾶλος, πειράω, and το πτερύγιον, and I submit them to your criticism, because the changes which I shall propose in the manner of translating them in some places appear to me to be more correct, according, at any rate, to modern usage of English words, and also to render the narratives in which they occur more in accordance with the events they relate.

Διδάσκᾶλος is generally, although not always, translated "master" in the authorised version of the New Testament, and while, in most places, this renders its meaning accurately, there are others in which it does not convey the true sense, but leads to misapprehension that would be removed if the word "teacher" was substituted for "master."

The other word, πειράω, though sometimes translated "prove," is generally translated "tempt," as if the two words were identical in meaning. I submit that, in several cases, the true sense of the passage would be more accurately rendered by substituting the word "prove," or "test," for the word "tempt," and that valuable instruction would then be found in the narrative which is now obscured or lost. The changes which I am about to submit to you are, therefore, the substitution of "teacher" for "master" in certain places, and of "prove" or "test" for "tempt" in others.*

* It is unnecessary to inform scholars that "tempt" has been used in English as an equivalent for "prove," without necessarily implying a bad

The passages which principally illustrate the case are found in St. Luke x. 25; in St. Mark xii. 28; and St. Matthew xxii. 34 and 35: "A certain lawyer stood up and *tempted* him, saying, *Master*, what shall I do to inherit eternal life?"—(ἐκπειράζων and Διδάσκἄλε)—Luke x. 25.

In St. Mark, one of the Scribes, having heard them reasoning, and perceiving that he answered them well,

sense, not only in the authorised version of the New Testament, but also by Spencer (rarely), by Shakespeare (more rarely still), and in one or two instances so lately as by Dryden. But the first two authors are of an earlier date than the authorised version; and the word "tempt," as meaning simply "prove" or "try," has practically disappeared from modern English. The Bible is intended for the use not only of scholars, but of unlearned people; and "lead us not into *temptation*," and "to be *tempted* of the devil," have so stamped an evil sense upon the word, that such an interpretation would naturally be put upon it at the present day, unless it was expressly contradicted. The following quotations from modern authors upon the passages commented upon in the following Paper, show that "prove" or "try" is not universally accepted by "teachers" as the sense of πειράω in these passages.

Dean Alford, in his New Testament, retains "tempting him" as the translation, and adds a note that the circumstances would not appear to indicate a malicious intention on the part of the lawyer in putting the question; but he does not point out what circumstances in these instances remove the evil sense from "*tempting* him."

The two English versions of the Bible, authorised by the Roman Catholic Hierarchy of Ireland and America, employ "tempt," both in Matthew and Luke, but without comment, though they have a note explaining that "tempt," in Genesis xxii. 1, means simply "try."

Davies (*Scripture Manuals* for use in tuition) distinctly attributes a bad sense to it, both in Matt. and Luke; and Stock (*Lessons on the Life of Our Lord*, published by the "Church of England Sunday School Institute, for the use of Sunday School Teachers,) attributes the sense of "probable curiosity, if not malice," "perhaps perplex Him," "get hasty answer." *The Cambridge Bible for Schools* adopts a bad sense, and Pulliblank (*Teacher's Handbook*) sends us to ask a Scholar what the Bible means by the word. These examples, from modern Scripture teachers, appear to furnish sufficient reason for desiring, in a Book which is to be read by all —learned and unlearned alike—and which is the great lesson Book of the Christian world, the substitution, where appropriate, of a word to which no evil attaches—"*prove*"—for the word "*tempt*," to which evil does attach generally, if not always, in modern English. To show where such a change is called for is the object of the present Paper.

"asked" him (ἐπηρώτησεν αυτον), "Which is the first commandment of all?" and this same event is related somewhat differently, as follows, by St. Matthew:—"But when the Pharisees had heard that he had put the Saducees to silence, they were gathered together. Then one of them, which was a lawyer, asked him, *tempting* him (πειράζων), and saying, Master (Διδάσκᾶλε), which is the great commandment in the law?" Premising that Διδάσκᾶλος means literally "teacher," we see that to translate it "master" is to apply to it an acknowledgment of respect and submission which does not necessarily belong to it. A man may teach truth or error and still be a teacher, and he may be acknowledged and submitted to as a true teacher, or he may be repudiated as a false one.

In the one case he might naturally be thought of as "master" by his attached hearers, while in the other case he would only be addressed as "Master" in scorn by those who rejected his teaching. But he might still receive the appellation of "Teacher" as a term of indifferent signification, both from those who disputed his authority, and from others who were still simply in doubt, and desiring to satisfy themselves.

Let us now try to put ourselves in the position occupied by this teacher and his hearers at the times described in these narratives.

An eloquent preacher had recently made his appearance on the banks of the Jordan, and had told his hearers of some one who would succeed him, and do still more than he had done; and some one had, in fact, succeeded him, and gone about the country and villages teaching, and, according to popular rumour, doing many remarkable works also, such as healing the sick, etc. Now, his "teaching" would appear to have been of an unusual character, for it is described by one of his hearers as follows:—"The people were astonished,

for he *taught* (ἦν γαρ διδάσκων) them as one having authority." This teaching and wonder-working continued, and the noise of it was spread abroad, until the rulers and people in high places heard of it, and began to take notice of it; but his teaching was opposed to the orthodox schools of the time, and his practice, in many instances, was opposed to the habits of the day; for he did many of his most wonderful and merciful deeds on the Sabbath. He was also followed by large multitudes, with the expectation on their part that he would eventually become their king and military leader against the Romans, though he himself never assumed this position, but rather appeared to shrink from it.

Now, in this position of affairs, learned men and official teachers of the people came to hear him, and judge for themselves of his claim to respect. And some even went further, and put questions to him to "*prove*" him. One of these, having listened to various questions put by men who appeared desirous of tripping him up, "entangling him in his talk," and "having perceived that he had answered them wisely," puts his own question—"Which is the first commandment of all?"—Mark xii. 28. Now, here we have a simple, but very important, question put by an apparently thoughtful and earnest man, without any complimentary preface, and without any express purpose being mentioned by the narrator, Mark. But another historian (Matthew xxii. 35), relating the same events, and the same question, describes it at greater length, and says that the lawyer addressed him with the courtesy-title of "Teacher." (Διδάσκᾶλε.) Now, in this title there is nothing which implies more than the recognition of the fact that the man whom he was addressing was a teacher. It neither acknowledges nor repudiates his right to be a teacher; and it implies neither the scoffing nor the recognition of his authority, which is implied (according to modern usage) by the term "Master," employed in the authorised

version, as the translation of Διδάσκαλε. But the narrative proceeds—"He asked him a question, *tempting* him." Now, I think that very few persons read this narrative without receiving the impression that the lawyer was scoffing at the person he was addressing by calling him "Master," while, at the same time, he was trying to trip him up by his question—was, in fact, "*tempting*" him in the ordinary sense of the word.* But the account of the same events already given by Mark produces no such impression about either the lawyer or his question, and if πειράζων was here translated "proving" or "testing," instead of "tempting," the whole character of the narrative in Matthew would be changed, and we should have simply an account of a thoughtful man, who, having seen that this new teacher had answered others wisely, but being still in some doubt about his character, puts his own test or trial question, "'Teacher,' which is the great commandment of the law?"

We can imagine this lawyer questioning within himself, "Now will he say, 'Thou shalt love thy neighbour (the Jew), and hate thine enemy (the Roman)' hoping himself to gain popularity, and become a king of the people. Or will he say, 'Thou shalt do no manner of work on the Sabbath day,' which is the popular cry of so many of the upper classes. Or will he say, 'If any man shall say Corban—it is a gift—he has fulfilled the law,' in order to curry favour with the priests. Or will he say that prayers in public places and ostentatious ceremonial and sacrifices are the great duty of man. Does he indeed himself know what is the great commandment of the law while he is professing to teach others?"

The question appears to have been received with an unhesitating acknowledgment of its honesty. And the answer with which we are familiar was at once given; and now the questioner's doubts were solved. He had "proved"

* See note on Davies, Stock, and others, p. 191.

the teacher, and was satisfied, and he acknowledged his satisfaction by the hearty rejoinder, "Good, Teacher, thou hast said the truth," and after that no more questions were asked.

In the case (Luke x. 25) in which another lawyer "tempted" him by asking what he should do to inherit eternal life, there does not appear to have been the same entire honesty of purpose; for, after receiving his answer, this lawyer tried to justify himself, and received a qualified reproof. Yet even here the whole tenor of the account is inconsistent with what we usually attribute to the word "tempt."

The lawyer asks a question (ἐκπειράζων), which is a legitimate one for a person to put who wishes to "prove" a teacher or to solve a doubt. "Teacher, what shall I do to inherit eternal life?" And the answer does not imply doubt as to the honesty of the enquirer's purpose, but rather as to his readiness to comply with the answer when given. He is accordingly questioned (tested) in his turn. "What is written in the law? How do you yourself understand it?" and the lawyer, in reply, gives the same "great commandment" which we have already commented upon. The teacher acknowledges the correctness of the answer. "Thou hast answered right — do this." But now the lawyer's infirmity of purpose or imperfection of knowledge comes to light. He wishes to justify himself for loving his neighbour (the Jew), but at the same time hating the Roman or the Samaritan, and the answer, and, at the same time, the gentle reproof of this double-minded temper, is given in the parable of the good Samaritan. But throughout the account of this conversation there is nothing which appears to bear out the modern sense of "tempting," either in the question asked, or in the manner in which it was received and answered.

In another instance, a somewhat similar question was asked, but under different circumstances; and the difference

sufficiently accounts for the propriety of the word "master" in the one case, while "teacher" seems the most correct in the other. A certain *young* man "came" to him, apparently on purpose to ask the question, and addressed him as "Good Master, what good thing shall I do?" etc. He appears to have been what would be called a good young man, and there is nothing but what is strictly natural in such a youth heartily acknowledging the "teacher" as master, and—being rich also—in addressing him by the half-patronising, half-respectful and deferential title of "Good Master." In this case it would be unnecessary to change the translation, for it is consistent with the whole story, and expresses completely the mutual feelings of the good rich youth, and the pitying loving teacher to whom he came.

In proposing these changes of translation of Διδάσκᾰλὸς and πειράω, no departure is made from examples furnished by the authorised version itself, in which the words are frequently rendered, by "teach" and "prove." The following examples will be familar to us all. "His teaching (διδάσκων) was with authority."—Matt. vii. 29. "They entered into the temple and taught (ἐδίδασκον)."—Acts v. 21. "And daily in the temple they ceased not to teach (διδάσκοντες)."—Acts v. 42. And lastly, "He hath set first apostles, secondarily prophets, thirdly teachers (διδάσκᾰλους)"—the very word in question.—1 Corinth. xii. 28.

It is indeed by this title that, in his night visit to Jesus, Nicodemus addressed him, in the authorised version. Nicodemus was manifestly uncertain about the claim and authority of this new teacher, and accordingly came to converse with him, and he commenced, "We know that thou art a 'teacher' (Διδάσκᾰλος) come from God, for no man can do the works that thou doest, except God be with him." Here the authorised version has recognised that, in a case where the speaker is in doubt, "teacher" is the proper interpreta-

tion of the same word, which is rightly translated "master" when disciples are speaking, and which is also translated "master" when men, such as the Herodians, addressed him with hypocritical respect, in order afterwards to betray him; or when others, like the Pharisees, addressed him scornfully by this title, when saying, "Master, rebuke thy disciples."

The rejoinder made to Nicodemus—"Art thou a master of Israel and knowest not these things?" appears to me to gain great additional point by translating the Greek word as "teacher" instead of "master," when it would read, "Art thou a teacher of Israel and knowest not?" etc. And this change is borne out by the ancient Welsh versions of Wm. Salesbury and Bishop Morgan, which give greater point still, by using a word which signifies distinguished, or eminent, teacher. "Art thou a distinguished teacher, and ignorant?" etc. The Geneva or "Breeches" Bible also translates it "teacher," and so also do the French and Italian, and the Old Sclavonic, or, as it is often called, the Russian Bible.

On comparison of the authorised version with other independent versions of πειράω, we find that scarcely any of them support the use of an ambiguous word like "tempt." In Genesis xxii. 1, the authorised version reads—"It came to pass after these things that God did '*tempt*' Abraham," a phrase which, in modern English, gives an impression of a more or less painful or doubtful character. But in the Septuagint, the Hebrew word Nissah (נִסָּה), which we have translated "tempt," is rendered by ἐπείρασε, "tried," which conveys no such impression.

Ulfilla's Gothic translation of the Gospels (4th century) uses "fraisands," "trying," "proving."

The Old Sclavonic, or the Church Sclavonic, sometimes called the Russian Bible, which dates back to the tenth century, uses the word "iskushashe," which means "try,"

"prove;" and Tyndal, Cranmer, and the Geneva, or "Breeches" Bible, say, "God did *prove* Abraham." Wycliffe employs the very striking word "God *assaiade* Abraham." The German Bible says "versuchte," tried; the French, "éprouvant," proving; the Italian (Diodati's), "provò," proved; the Spanish, "probo," which has the same meaning. The Welsh Bible, translated by Wm. Salesbury in 1567, and that translated by Bishop Morgan into Welsh in 1588 (both of them many years before the authorised version), both say "profit," "proved," which is retained in the more modern Welsh version now in common use.

The Irish Bible, "Bedell's" (commenced in 1629), uses "theasduigh," "tested," "tried" (from "teast," prove, try), in Genesis xxii. 1, in speaking of the lawyer's question in Matthew xxii. 35, and also in the question put to "try" Philip in John vi. 6. But it employs a different word, of a somewhat striking character, in speaking of Abraham's trial in Heb. xi. 17. "Do dhearbhadh," "he was proved," from "deart," which means "reality;" "dèarburg," "to make sure that a thing is real," to show that his faith was real. It uses the word "cathughadh," with a bad signification, in describing the temptation of our Lord by the devil, and also in the account of the lawyer's question given by Luke x. 25. The root of this word is "cat" or "kát," a fight. "Catugad," "the act of fighting," or "tempting, for temptation is a fight."—(Very Rev. Canon Bourke, President of St. Jarlath's College, Author of the *College Irish Grammar*.)*

* The Irish, as a written language, is so much less known than many others, that I have found great difficulty in obtaining a translation of those portions of the Irish Bible which were necessary for this Paper. I gladly avail myself of this opportunity of thanking the Very Rev. Canon Bourke for his hearty response and the valuable information he has given me. The following interesting account of the Irish Bible, commonly called Bedell's Bible, is added from his pen:—"Bedell (William) was Pro-

On the other hand, a folio edition of the Vulgate, published in Rome in 1486, uses "tēptavit," a simple contraction for "temptavit," but another folio edition, published in Nuremberg in 1479, employs the word "optavit," and the Hexaglot edition employs "tentavit," simply "tried." The Douay version of 1609, translated from the Vulgate, naturally adopts the Latin form, and translates it, "God *tempted* Abraham," and Coverdale also, in his English Bible, uses "God *tempted* Abraham."

It is interesting to observe the change which has taken place in Latin, as well as in English, with respect to the word "tempt." It has been already mentioned that one

testant Bishop of Kilmore, in Ireland. He was born December, 1571, at Black Notley, in Essex, educated at Cambridge; and was eight years a chaplain to Sir H. Watton, English Ambassador at Venice. There he devoted himself to Greek and Hebrew, under the chief of the Jewish synagogue, and Fra Paolo. Returning to England, he married the widow of the Recorder of the town of Bury St. Edmunds. In 1615, he was made Rector of Horningheath; and, after twelve years, he was appointed to the Provostship of Trinity College, Dublin. He there wished to see the young aspirants to the (Protestant) Evangelical Clerical state learn the language of the Irish people; and was the first (in practice) to set on foot an Irish class. In 1629, he was made Bishop (Evangelical) of Kilmore, in Ireland. Then it was he set about to translate the old Bible into Irish. He did this chiefly by the aid of two Irish Catholic Friars, who received from him shelter and support. At that time they were exiles in their own land. He, however, revised their work, because he knew the Hebrew version, and the Septuagent well. He had types cast and brought to his own house. The war of 1641 was the beginning and end of his trials. Though treated with marked respect by the Irish—by priests and people—yet he suffered much by being, in 1642, put out of his own home and sent to another. At the end of that year he died. A new (Protestant) Church has been, in 1860, erected at Kilmore to his memory. The 'translation,' then, of the Irish Bible is rather a 'Catholic' than a 'Protestant' version. It has no authority for correctness, except that of the learning and known truthfulness of Bishop Bedell. He lived so correctly, as compared with other Evangelisers of the period, that, when he died, he was buried with all the pomp Irishmen could bestow, and it is said that they repeated, whenever his name was named—'requiescat in pace.' He was a good scholar. He was (naturally) a good man. The authority of his translation rests only on his personal qualifications."

edition of the Vulgate uses *tempto*, while another employs *tento* in the same passage; and it appears that, in classical Latin, the two words were used indiscriminately, except that *tempto* is the most ancient form of the word. Virgil and Terence illustrate this point, the quotations being taken by Wagner from the best MSS. of Virgil, in the Library of San Lorenzo, at Florence. Bentley also says, in commenting on the Phormio of Terence, that the MSS. of 1200 years agree in reading *temptare* or *temtare*, not *tentare*, which latter mode of spelling is an innovation. Dr. Smith's dictionary says upon this point—"Marini proves from numerous inscriptions on monuments (lapidibus) of the highest authority, that the spelling '*tempto*' was generally adopted by the Romans."

In the 1st Georgic, l. 207, Virgil says that "the sea and the oyster-bearing straits of Abydos are tried or examined (*temptantur*) by the sailors." In the 2nd Georgic, l. 247, he is speaking of apples and unripe grapes that look juicy and tempting, but the "wry mouths of those who *try* them (*ora tristia temptantur*) soon show what their real character is." And in the 4th Georgic, l. 194, Virgil says, "that in stormy weather, and when the east wind is blowing, the bees do not wander far from home, but *try* short excursions into the fields within easy reach of shelter." "Excursus breves *temptant*." In all these cases, modern editions of Virgil spell the word in the later fashion, as "tentant," "tentantum," and "tentantur."

With respect to the substitution of "prove" or "try" for "tempt," in the questions put by the lawyers under consideration, there is a remarkable agreement in the different versions. The Greek, as we know, uses the simple sense of *πειράω*, to try; the Vulgate employs "temptans," which, as we have seen, was the original form of "tento;" the German adopts "versuchte," tried; the French "pour l'éprouver," to

prove him; the Italian "tentandolo," to prove, to experiment, to try; and the Spanish "por tentarle," with similar meanings; the ancient Welsh of Salesbury uses "brovi," to "prove" him, in Matthew; but "demtiaw," "tempted" him, in a bad sense, in Luke. Though the original Greek is the same in both cases, there is not the same unreserved simplicity of purpose in the one lawyer as in the other, which probably accounts for the difference. A similar difference is made in the Irish version, which gives "theasduigh," "tried," in Matthew, but "cathughadh," "fought," "tempted," in a bad sense, in Luke.

On the other hand, we have, in support of an unfavourable meaning, Morgan's Welsh Bible which uses "demtiaw," which has a bad sense, and the modern sense of the Russian version, which employs "iskooshaiyah," "tempting" him, in a bad sense, corresponding with the prayer, "lead us not into *temptation*," while the original meaning of the word in Old Sclavonic was simply "try," "prove." The most ancient English version (Wycliffe's) is curious as an illustration of the absence of any bad sense necessarily attached to the word "tempt" in the English of his day, for he employs the word "tempt" in translating a passage in John, which is translated "prove" in every other version except the Vulgate. The word occurs in the account of the miracle of feeding the multitude. Jesus asked Philip, "Whence shall we buy bread that these may eat? and this he said to *prove* him, for he himself knew what he would do." Here our authorised version translates πειράω by *prove*, while in other places it has translated the same word by *tempt*, and all the other versions we have passed under review, except the Vulgate (the Gothic, Tyndal, Cranmer, Coverdale, the Bishops, German, French, Italian, Spanish, Irish, Welsh, and Russian), employ words meaning, unequivocally, "prove." Wycliffe, however, as I have said, employs the word "tempt" in this instance, and says, "he

said this thing *tempting* him, for he wist what he was to do." The Vulgate also employs the word "temptans" in this case "hoc autem dicebat temptans eum," in accordance with its employment of this word as the original form of "tento," to try.

It is interesting to observe how "tempt" in English has followed what seems almost to be a law of language, viz., that whenever a bad sense begins to be attached to a word it gradually becomes the only sense in which it is used.

We have seen that in Wycliffe's days it was used as a mere expression of trial or proof; but, at the present time, I am not aware of a single instance in which it is employed without, at any rate, an unfavourable, if not absolutely evil, sense being attached to it. This very general statement may seem to some persons to be at variance with the use of the word in such cases as—"The weather was so tempting that we made our excursion;" "I was tempted by the beauty of the picture to buy it;" or "by the ripeness of the fruit to eat it." But, if we think a moment, we shall all feel that the complete sentences would naturally be—"The weather was so tempting that we made our excursion, but it changed while we were out, and we came back wet through." "I was tempted by the beauty of the picture, but I was afraid it would be too extravagant to treat myself to it." "I was tempted by the ripeness of the fruit to eat some, but I had to pay a doctor's bill afterwards in consequence." We shall find that in every case in which we use the word "tempt," even when most apparently harmless, there is some drawback of evil connected with it, slight though it may be.

There is a compound form of the word, viz., "to attempt," "to try," which seems as if it, at any rate, was free from evil, yet even in this word we find a root of bitterness. I believe we shall discover, on careful examination, that whenever we employ this word, we do so with an anticipation, more

or less defined, of possible failure in the result. For example —"He made the attempt" (but failed); "I will make the attempt" (but I am doubtful about the result); while the phrase, "In whatever you undertake, try your very best," implies no warning of probable failure. "The trial of the new horse was very satisfactory, though his attempt at the last leap was a failure," sounds perfectly natural. That the *trial* should be satisfactory, while the *attempt* was a failure, is quite in accordance with our usual mode of estimating and using these two words—the word "attempt" carrying with it the evil spirit of its ancestor, "tempt."

Nearly all the versions agree in imparting a bad sense to the "trial" or "temptation" of our Lord by the devil; and while upon this portion of the subject, we may notice, incidentally, the curious and (so far as I can discover) the inexplicable translation of το πτερύγιον by "*a* pinnacle." "Then the devil taketh him into the holy city, and setteth him upon '*a* pinnacle' of the temple." The Greek article το is perfectly definite, and πτερύγιον also means a "wing" of a building, not a pointed structure such as we now understand by a "pinnacle;" and if the translation was correctly made, the difficulty would at once disappear of two persons standing and conversing upon the top of a pinnacle, which the present translation has been supposed to imply. I have not found in other versions any confirmation of the English expression, "*a* pinnacle," for the Greek is unequivocally "*the* wing," as if it was some well-known elevated portion of the temple, from which the city was wont to be viewed; such as will at once come to mind when we think of *the* Tower of York Minster; *the* Eagle Tower in Carnarvon Castle; *the* turret of Milan Cathedral, etc. Latin has no articles, and therefore we do not look for one in the Vulgate, which says, "supra pinnaculum," "upon the pinnacle." The Italian has "l'orlo del tetto," "*the* crest of the roof;"

the Spanish has "la almena," "the battlement or turret;" the French has "sur le haut du temple," "upon the summit of the temple;" the German "die zinne," "*the* most elevated part of a building;" the Old Sclavonic (the Russian) has no articles, but says, "krilye tur kovnyam," "wing of the church;" and Mr. Russell Martineau, Librarian in the British Museum, and an accomplished Russian scholar, writes to me upon this subject, that if it meant "a wing," some such phrase would be used as "a certain wing," corresponding with the expression, "a certain lawyer stood up." In like manner, the Welsh Bible has no articles, but says "bistacul or pinnacul," which implies, according to Welsh scholars, some definite and well-understood object. The Irish has an article, though it is not present in its version. "Air bhinn an teampuill," which means "on *the* gable or pinnacle of *the* temple," for, when a noun comes before a genitive, the definite article is understood before each. "On gable of temple" means, therefore, "on *the* gable of *the* temple." Bhinn, in Irish, means "gable of a roof," "any pointed summit of a hill," and corresponds with "Ben-Lomond," etc., in Scotch, "Pen-igent" in Yorkshire. The most ancient English version also (Wycliffe's) has "*the* pynacle," and it is a curious point to ascertain why "the" of Wycliffe and the Greek was changed into "a" by Tyndal, whose example appears to have been followed by Cranmer, Coverdale, the Geneva Bible, the Bishops' Bible, and, lastly, by our own authorised version. No controversial question was involved in the change, and it is curious how such an error should have crept in and been repeated by so many able scholars.

The translation of the Greek πτερύγιον, "wing," into the Latin "pinnaculum," from "pinna," a wing, would seem to be the origin of the English employment of "pinnacle," which, at first, meant "a wing of a building," and not (as

in the present day) a pointed structure; but it has gradually acquired its present signification by one of those changes in language which are continually going on in every living spoken tongue.

In conclusion, then, I commend to you the substitution of the definite word "prove" or "try" for the ambiguous one, "tempt," in the translation relating to the lawyers and their questions contained in Matthew and Luke; that of "teacher" for "master" in the same narratives, and in the conversation between Jesus and Nicodemus, related in the 3rd Chapter of John's Gospel; and also the change of "a pinnacle" into "the wing of the temple," as bringing out the real meaning of the events more correctly, and removing incorrect impressions which are attached to the present translation in the authorised version.

In the discussion Rabbi Prag said:—

"The Hebrew equivalent for πειράω is נסה, and in expressing the actions to try, to tempt, to prove, also to make *experiments, to experience* (derived from the Greek πειράω), is found in no other form of conjugation but in the piel (intensive, causative), viz., נִסָּה.

"This verb evidently belongs to that defective class which drop the first radical letter נ in conjugation (פ״נ), and of which the piel and the niphal have an equal construction. נִסָּה may therefore be rendered in the simple passive [niphal], *he was tempted,* as well as in the intensive active [piel], *he has tempted.* Instances of this kind are of frequent occurrence in the Hebrew Scriptures, *e.g.*, וְנִגַּשׂ (Isaiah iii. 5) may be rendered, '*they shall oppress one another,*' as well as '*they shall be oppressed by one another;*' נִשֵּׂא (1 Kings ix. 11) is active (piel), whilst נִשָּׂא (Exod. xxv. 28, and 2 Kings xx. 17) is passive (niphal). By this it is suggested that the word נִסָּה in the passage, '*and God tempted Abraham*' (Gen. xxii. 1), may have an *objective* meaning, conveying to us not

that God led Abraham into temptation—far be it from the Allwise to tempt frail humanity—but that a command of such a nature, viz., to sacrifice an only son, would, to an ordinary man, be a trial of faith, an incentive to disobedience, a temptation. נִסָּה in this form occurs only once more in the Hebrew Scriptures (1 Samuel xxii. 39); the passage, 'he had not *proved* it,' would be more correctly rendered, 'he had no *experience* with it.'

"In Deuteronomy vii. 19, and xxix. 3, we read, '*the great temptations which thine eyes have seen,*' etc. What the temptations were to which the sacred writer alludes is nowhere explained; but on rendering the term מַסּוֹת, *experiments,* instead of *temptations,* the meaning of these passages will be fully understood. The proper version of them would be the following: 'The great experiments which thine eyes have seen [the experiences thou hast gained]—by signs and wonders—of the mighty hand and outstretched arm,' etc.

"Men tempting God, as, '*you shall not tempt the Lord your God*' (Deut. vi. 16), '*when your fathers tempted me*' (Psalm xcv. 9), means disbelief, making *experiments,* and requiring proofs of God's presence and power, wisdom and goodness. Men try God when they expose themselves to danger, waiting for a miraculous interposition of Providence, as well as when they sin with boldness, disbelieving in the Omniscience of God. The sense of the verse, Ps. xcv. 9, would be, 'your fathers tempted me, made experiments with me, though they had experience of me by seeing my works.' (Compare Psalm lxx. and Malachi iii. 15.)"

THE LEVANTINE PLAGUE—PAST AND PRESENT.

By FRANCIS IMLACH, M.D.

Recent events have reminded us that Plague, the Black Death, the Great Mortality, is a thing of the present as well as of the past. For the last few years it has spread over Persia in epidemic proportions, and in January of this year, if not before, overleaped its Persian bounds and invaded both shores of the lower Volga. Isolated cases have occurred extensively throughout Russia, and it is said to have appeared even in St. Petersburg. When, therefore, we learn that the ice broke up in the middle of March, and that ships from the Baltic, laden with rags, have actually reached British seaports, we may well fear that the Plague may be for us a thing of the immediate future. A fever is not to be feared merely from the gravity of the symptoms it produces in the individual, but also from the rapidity and certainty with which it extends from one individual to another, from house to house, in spite of all precautions, so that a single case may be the sure sign of the death of perhaps half the inhabitants of a town. A study of it, as it appears in the individual, its symptoms and their treatment, are for the physician; but its reappearance from time to time, and extension from place to place, in short, its history, is matter of interest for all. And my purpose, accordingly, is to give a brief sketch of the chief European epidemics of this one great and worst form of fever. I must, indeed, admit it to be a picture of shadow without light, a monotone of misery without hope, and only to be justified by the immediate need

of the lesson it may teach. The tragedy *is* coming, must *we* be unwilling actors?

We first hear of the plague in 430 B.C., and it may be safely said that any other time and any other place might have been doubly stricken with less consequence to mankind. Athens was in her glory. The thirty years' truce had just closed. Another town would have grown rich by commerce, Athens grew rich from within her walls, and the culture of such men as Pindar, Æschilus, Sophocles, and Phidias has made her famous through all ages.

But misfortune came upon her. Just a year before, the great Peloponnesian war had commenced. The inhabitants of Attica, leaving land and cattle to their fate, fled into the city, finding shelter in the towers and recesses of the city walls, in sheds, cabins, tents, or even tubs. Athens might withstand the opposed forces, but this crowding with her dependents made her receptive to a mightier fate. Plague, some time back, had started out of Ethiopia, passed thence into Egypt and Lybia, and overrun Persia. It was carried along the coast line of the Mediterranean, and finally began to do its worst in Athens, in the beginning of April. From the Peireus it passed into the city, and spread throughout its inhabitants. The seizures were sudden, and almost all the sufferers perished, after deplorable agonies, on the seventh or ninth day. Priests tried charms and incantations; physicians tried bonfires, and their more ordinary arts; but all without avail. The people lost hope, and the dead and dying lay uncared for, piled one upon another, in close-packed crowds, in the public roads, the temples, and the houses. "In some cases, the bearers of a body, passing by a funeral pile on which another body was burning, would put their own there to be burnt also; or, perhaps, if the pile was prepared ready for a body not yet arrived, would deposit their own upon it, set fire to the pile, and then depart." All

sense of honour, all sense of shame, were lost. Profligacy and theft were the natural product of hunger and misery, and these increased, while the hold of the law diminished. Statistics is a modern science, and the exact enumeration of the dead must not be looked for. Ten thousand is the number mentioned, but that only meant a great many, and is probably much too low an estimate. During the second and third years of the war it continued, after which it abated for a year and a half, but revived again to last another year with the same fury as before.

Such is the story of an ancient epidemic, in which Socrates was a sufferer, and of which Hippocrates was the observer, and Thucydides the historian.

It has been much questioned whether or not this disease was true oriental plague; and some have called it eruptive typhoid, and others small-pox. When one reads the work of Hippocrates upon Epidemics, one cannot but remark that, while the description of individual cases is often vivid and exact, his classification is vague and misleading. Indeed, in fevers, it is remarkable how slow has been the progress from the general to the special, and I think it will be admitted that even at the present day we are but a little further forward on our way towards an accurate classification of fevers, and still far from its completion. This progress, such as it has been, is apt to mislead us, and has so far prevented us from determining a very important question, namely, whether fevers alter in their character from age to age, or whether they have been the same in type throughout historic times. Evolution in the observers has hidden evolution in the things observed. Influenza, acute dysentery, and plague were undoubtedly known to and described by Hippocrates, but it is surprising how recent are our first distinct intimations of the various fevers with which we are now, unfortunately, so familiar. Such a well-marked and terrible

disease as small-pox was, of course, amongst the earliest noted, and in A.D. 569 (the birth-year of Mahomet) was distinctly described, though all knowledge of it seems to have died out again until its re-discovery by the Arabian physician, Rhazes, in 910. Croup and measles were only imperfectly known in England in the fourteenth and fifteenth centuries, and until the seventeenth century hooping-cough was often confounded with them, as also was scarlet fever, until Sydenham, our great English physician, published his well-known account of it in 1676. Chicken-pox was not disentangled from allied complaints until Fuller's time, in 1730; and vaccinia, as every one knows, was first described by Edward Jenner in 1768. Not until some time after our occupation of India was cholera discovered; and dengue, a vexatious though apparently mild fever of that empire, appears to be still almost unknown. And as for typhus and typhoid, those fatal and depressing fevers of stagnant ponds and crowded dwellings, they were only differentiated in 1849 and 1851, by men still living—Stewart, and Sir William Jenner.

So, then, we have no right to expect much precision in ancient, and often non-medical, writers. Enough that they mention the low fever and depression, the swelled and suppurating glands, the fatal token of the purple spot and carbuncle, with death too frequently on the third or fourth day. Such a disease, spreading through a town, and following the tracks of commerce, we must be content to know as the *plague*.

We must pass over a period of nearly a thousand years before we again meet with the Great Mortality. Doubtless it was still endemic in Egypt, and isolated cases occurred now and then throughout the Levant; but, as a matter of fact, until the reign of the great Emperor Justinian, plague

was forgotten, or at the most only remembered by historians and other quite unpractical men. But, in A.D. 526, Constantinople was shaken during forty days by a great earthquake, which was felt, indeed, throughout the whole Roman empire. Enormous chasms opened, huge and heavy bodies were discharged into the air, the sea alternately advanced and retreated beyond its ordinary bounds, and a mountain was torn from Libanus and cast into the waves. Two hundred and fifty thousand persons are said to have perished in an earthquake in Antioch. Again, in September, A.D. 531, the fifth year of the emperor's reign, a great and mysterious comet was seen during twenty days in the western quarter of the heavens, which shot its rays into the north. Such a sign, in the excited imaginations of the people, portended some grave evil to the State, but fortunately brought forth none. But, eight years later, while the sun was in Capricorn, another comet followed in the Sagittarius, its head in the east, its tail in the west, its size increasing, and its departure delayed for forty days. Now, indeed, calamities were to be looked for, and the astronomers were eagerly questioned. Only three years had the people to wait for an answer. In A.D. 542, dread plague overspread the empire. It had arisen, it was said, in the neighbourhood of Pelusium, between the Serbonian bog and the eastern channel of the Nile, and thence it could be tracked both east and west—east through Syria, Persia, and the Indies, west through the north coast of Africa and over the continent of Europe. Fed afresh from Persia, wherever it abated, fifty-two years passed before Europe was freed from the pestilence. In Constantinople, during three months, from five to ten thousand persons died each day. Deep pits were dug outside many of the towns, but when these were filled the dead lay undisturbed. Details of this, perhaps the worst and greatest of all epidemics that have occurred, are not to be had, although

Procopius, the secretary of Belisarius and historian to Justinian, has sufficiently shown its great severity. "The triple scourge of war, pestilence, and famine," says Gibbon, "afflicted the subjects of Justinian; and his reign is disgraced by a visible decrease of the human species, which has never been repaired, in some of the fairest countries of the globe."

"It is good in all times to bear about you precious stones (if ye have them), especially a jacinct, a ruby, a garnet, an emerald or sapphire, which hath a special virtue against the pestilence, and they be the stronger if they be borne against the naked skin, chiefly upon the fourth finger of the left hand, for that hath great affinity with the heart, above other members."

"A nut and a dry fig," sayeth Isaac, "taken afore dinner, preserveth a man from all manner of poisons."

"Those that use toads either bore a hole through their heads, and so hang them about their necks, or make troches of them, as *Helmont;* or encompass them with isinglass, and so hang them as before."

Such being a fair sample of recipes to which, in times of panic in the middle ages, the common people and the lower class of apothecaries and physicians resorted, one need not marvel that an epidemic, once commenced, in general proceeded on its march without being much disturbed by measures of repression. This was notably so in the case of the famous plague of 1348, which I must next describe. Before this the Crusades had occasionally reminded Europe of the existence of plague, but they were never the occasion of an epidemic.

Fifteen years previous to the outbreak of this plague in Europe, China suffered from climatal irregularities. Great

areas of that empire had, during several years, repeated alternations of drought and inundation; tillage failed, and famine followed. In 1333, over four hundred thousand people, in and about Kingsai, perished. In Canton, plague arose in addition, of which five million are said to have died, and six years later, four million in Kiang. Following the caravan routes through Central Asia, it entered Europe, north of the Caspian Sea, while, by the route south of the Caspian Sea, it infected Bagdad, and finally reached Syria and Egypt in 1348. During its prevalence in Cairo, the loss is estimated at from ten to fifteen thousand daily.

By the north route merchandise was brought to Tauris, north of the Black Sea, and shipped thence to Constantinople; and from this city the plague, which first appeared there about 1346, rapidly spread through Western Europe.

And at this time, too, as in the epidemic of A.D. 542, ominous portents were not wanting. An unexampled earthquake shook Greece, Italy, and the neighbouring countries. Great and extraordinary meteors appeared in many places. A pillar of fire, on 20th December, 1348, remained for an hour at sunrise over the Pope's palace in Avignon; and in August of the same year a fireball was seen at sunset over Paris. There is still better evidence that famine was very prevalent throughout Europe. It is easy to cast ridicule upon the often-repeated attempts to show the influence of astronomical events over human affairs, and more particularly human disasters. But one must, I think, by the principle of continuity in nature, admit some relationship between these two phenomena, and, although doubtless for the most part the causation established by man has not been that established by nature, still, recent scientific investigations on the connection of famine with sun-spots, give us reason to believe that an old field, long fallow, may yet yield sound fruit. Smyrna, Candia, Sicily, and Marseilles were all attacked by

plague in the same year. Marseilles lost sixteen thousand people in one month. It was, and had for a long time been, the principal port for vessels from the Levant. In olden times, when afflicted with plague, they had a custom which reminds us of a similar one in ancient Mexico. "Their manner at such times was, that some one poor man offered himself to be maintained at the public expense with delicate food for a whole year; at the end of which he was led about the city dressed in consecrated garments and herbs; and being loaded with curses as he went along, that the evils of the citizens might fall upon him, he was at last thrown into the sea."

In 1348 it reached Rome, where it maintained its hold for three years. About the same time, Florence and Venice, and the neighbouring towns, were seized with like fatal result. From Marseilles it quickly passed to Avignon, the temporary home of the Popes, and thence to Spain, in 1350. In 1349, Strasburg became a centre of infection to the surrounding countries. While France was being devastated, to such an extent, it is said, that not more than two in twenty of the inhabitants remained alive, the plague was carried over to Dorset, whence it advanced through the counties of Devon and Somerset to Bristol, and thence reached Gloucester, Oxford, and London, whose loss was one hundred thousand people. From Hull the contagion was carried to Bergen, the capital of Norway, where it broke out in so frightful a form that not more than a third of the inhabitants remained alive. Along the coast, the fishing villages were next attacked; the sailors found no refuge in their ships, and vessels were often seen driving about on the ocean, and drifting on shore, whose crews had perished to the last man.

From Strasburg, too, it found its way through all Germany. Lübeck, "the Venice of the north," to which multitudes flocked for safety, was ravaged no less than other towns.

Indeed, in Germany the plague was actively epidemic for several years, and in 1360 caused a second outbreak in Avignon so severe, that the Pope found it necessary to consecrate the Rhone, that bodies might be thrown into the river without delay, as the churchyards would no longer hold them. Poland was reached in 1349, but not until two years later did it spread into Russia, where, however, ten years elapsed before it abated.

Stricken with panic ere they were stricken with plague, the people of each town looked in vain to right and left, and up and down, for deliverance from pestilence and famine; but priest and physician, supplication, incantation, and charm alike failed them in their need. The people brought forth the traditional nostrums of former epidemics, while the doctors advertised their entirely new cures. But, unfortunately, proof of cure by old saw or new science was not forthcoming, and listless Oriental fatalism brooded over all. Three schools of medicine had each for a time their ardent disciples.

The College of Physicians of Paris issued a manifesto, in which they stated the cause of the plague to be deleterious vapours, which the sun and constellations in vain strove to disperse. They recommended the people, therefore, to shelter themselves from the corrupted vapours by the Hippocratic bonfire, and by staying indoors. Spicy potherbs were to be used at meals, while cold, moist, watery food was to be avoided. Going out at night, and even until three o'clock in the morning, was pronounced dangerous; and fat people were earnestly warned not to sit in the sunshine.

Avignon laid stress on astral influences, and believed that a conjunction of the stars caused an epidemic constitution against which it was for the most part quite hopeless to contend. But notwithstanding the grand conjunction of Saturn, Jupiter, and Mars, in the sign of Aquarius, which

took place, according to Guy de Chauliac, chief physician of the city, on the 24th March, 1345, symptoms must still be treated as they arose; bleeding, the red-hot iron and the knife were called upon to undo the mischief the stars had done, and an obedient but starved population yielded up to the monks what little blood it had to spare. Guy de Chauliac himself, however, doubted the good of bleeding the poor, and reserved this treatment for the most part, he says, for the papal courtiers. The advice he gave to many was, a precipitous flight from the city—" cede cito, longinquus abi, serusque reverte." But whether from political motives or otherwise, to his most illustrious client, Pope Clement VI., he recommended that he should shut himself up in his rooms, which were to be fumigated. The good Pope remained, indeed, in Avignon, but went about amongst the poor, lightening their misery with both spiritual and material comfort.

But it was from Perugia the most enlightened medical doctrines spread. Gentilis of Foligno, a celebrated professor in that place, neglecting astrological considerations altogether, laid it down that plague was undoubtedly contagious, that by contact of person with person it was spread from town to town, and that the corruption of the blood in the lungs and heart were occasioned by the pestilential effluvia from the dying and dead. Causation being thus narrowed, treatment became more determinate. In addition to the Hippocratic wood bonfire, sulphur was burnt in house and street, and the divine doctrine of cleanliness was strongly urged. The healthy washed with all the known disinfectants, and carried camphor with them as they went about.

For a time confidence was restored; governments got the clue to act, and carried out, indeed, with the rigour of barbaric times the suggested measures against the spread of contagion,—measures which have in recent years been successfully revived against the cattle-plague, without, how-

ever, any previous consultation with the cattle. Houses in which the plague had broken out were walled up and rigorously barricaded, or the patients were carried out of the city at dead of night, and thrown into the fields to perish. But the healthy still sickened and the sick still died, and the people became clamorous. A wide-spread disaffection against the priests prevented their acceptance of the comforts of the Church; vengeance against some one became their fixed desire, and flight from their native towns, no matter whither, their last desperate resort. A ready organisation for effecting their double purpose was found in the penitential processions of the Flagellants, which had been instituted two hundred years previously by St. Anthony, and which still maintained a languid and dubious existence. The penance enjoined fitted the humour of the time, and only swelled the crowd of aspirants. Morning and evening they set out singing psalms and tolling bells, till they arrived at the place of flagellation; there they stripped and lay down in a large circle in different positions according to the nature of their penance, and stripes were administered by their superiors with triple scourges tied in three or four knots and armed with cruel points of iron. Through Germany, Hungary, Poland, Bohemia, Silesia and Flanders their processions, with all the pomp and ceremony that banners of velvet and cloth of gold could lend, were seen in strange contrast with the rigour of their penance.

Contented to escape the plague, whether by flagellation or procession, by heavenly power or human ingenuity, the common people aimed at nothing more; but they were led by men who were ambitious, men who struggled to the front in order to have a power to back them in their designs against Church and State. In accordance with ancient custom, the Jews were the first to be attacked and plundered. This unhappy race was in connexion with secret superiors in

Toledo, who sent poison from afar, or instructions how to make it from spiders, owls, and other venomous animals, and how to poison springs and wells. Moreover, the murder of Christian children was proved against them, at least so rumour said, and there must be truth at its foundation. A general massacre accordingly was determined upon, and preached from town to town. An oath of extermination was taken, but was not fully carried out. It is true that in Mayence twelve thousand Jews were put to a cruel death, that in Basle a wooden building was specially constructed with a view to combustibility, the Jewish inhabitants locked in, the place fired to the ground, and an edict sent forth forbidding all Jews from entering the city for the space of two hundred years; and that at Spires, driven to despair, they set fire to their own dwellings, and so perished with their families. But there was a small party that could see only the fanaticism and not the justice of all this; and by the combined power of the Pope, Charles IV. of Germany, and Philip VI. of France, the Flagellants were disarmed and dispersed.

In 1630 all Europe was again alarmed by the appearance of true oriental plague at Ferrara, in Italy, but the epidemic abated without further extension, and alarm was silenced. Quietly, however, and irregularly, the plague werked its way from Constantinople through Turkey, Western Russia, and Poland, until, in 1652, it arrived in Dantzic, where it became more malignant than before, and spread more rapidly. Hamburg, Copenhagen, Amsterdam, and other cities of the north were quickly attacked, and in 1654 it had reached Arras, whence it was disseminated throughout France. But the greater part of Germany apparently remained free until 1660, and Austria until 1679. By the Mediterranean route Valencia was first attacked in 1647, and almost the whole of

Spain in the following year. In Sardinia, Rome, Genoa, and Naples it was very severe during 1656, especially in the last-named town. To England it was brought in 1664, by a vessel laden with cotton which had sailed from Smyrna to Holland, and thence to London. It broke out in a few houses in St. Giles-in-the-Field, slumbered through the winter, and, in the following year, as everyone knows, occurred the Black Plague of London, which caused the death of one hundred thousand people, and did not abate until after the great fire. It is, I think, sometimes forgotten that London is not the solitary instance in which a city has been swept by plague, but that it is merely an example of what at one time or another almost every large continental town has experienced. There is a well-authenticated pitiable tale connected with its occurrence in Dorset. The magistrates of Poole could find no one to attend upon the sick in hospital, and they therefore "engaged a young woman, then under sentence of death, in that service, on a promise to use their interest for obtaining her pardon. The young woman escaped the disease, but neglecting to solicit the Corporation for the accomplishment of their engagement with her, three or four months after she was barbarously hanged by the Mayor, upon a quarrel between them."

The south coast of France remained free from plague until 1720, when it ravaged with great vehemence Marseilles, Aix, and Toulon. Of the famous plague at Marseilles,—a city that could have no more appropriate patron than Saint Lazarus,—we have a detailed and authentic account. Over sixty thousand died of plague in six months, trade came to a standstill, and the town was apparently ruined, yet a few years later it was again the most flourishing and populous port in the Mediterranean.

On the 25th May, 1720, a vessel arrived at Marseilles from Syria with a clean bill of health, but the captain declared

that while he touched at Leghorn, six of his mariners had died of malignant fever, and on the 27th—two days later—a mariner died while the vessel lay in the harbour of Marseilles. Thereupon, the Magistrates of Health ordered the body to be examined by Guerera, first chirurgeon of the Practick, who reported there was not the least sign of contagion. Notwithstanding this, and in order to allay the fears of the inhabitants, a guard of quarantine was put on board the vessel. On the last day of May, three more vessels arrived from the East, this time with foul bills of health, for the prevalence of the epidemic in Syria was by that time acknowledged, and simultaneously one of the guard of quarantine died. A medical examination was again insisted upon, and again Guerera reported that there was not the least sign of contagion. But all the passengers were placed in the lazaretto and fumigated, and were only allowed to enter the city on the 14th June; and officers were placed on board to disinfect the merchandise. On the 23rd June two of these officers died of fever, and Surgeon Guerera again reported that there was not the slightest sign of contagion. Yet the dead bodies were interred in quicklime, their apparel burnt, and the ships were ordered to retire from the harbour to a small neighbouring isle to undergo a fresh quarantine. On the 28th June another bark arrived from the East with a foul bill of health, and the magistrates determined for the present to close the harbour against all vessels until they had passed through complete quarantine. On the 7th July two porters of quarantine fell ill. They were visited by Guerera, and though he found fever and characteristic swellings, yet he did not believe it to be anything of the plague. Official incapacity could stretch no further; next day the two porters and the surgeon all died. While on his deathbed, the poor fellow at length declared he saw signs of contagion, a consultation with three other medical men was held, and the existence of the

plague was officially announced to the Governor of the Province and the President of the Parliament of General Council. On the 9th July, in a house in Linche Street, a young man was reported ill of the plague; next day he died, and his only sister turned ill. The guard of quarantine removed the dead and dying in the night to a hospital outside the city, and walled up the doors of the house; search also was made through all the streets, and all suspected cases removed.

By the 21st the panic abated, and the authorities were freely ridiculed for their alarm; but on the 26th there were numerous cases of undoubted plague, and the people were again panic stricken. True to principles of trade, both ancient and modern, corn immediately went up excessively in price; true also to these same principles, bread riots quickly followed, and a paternal local government seized upon all the provisions, and doled them out according to its notion of justice. But the bread went too quickly, so all beggars were ordered, on pain of death, immediately to quit the city. When they reached its gates, however, troops of military were there to enforce an order from the central authorities forbidding all egress from Marseilles. Confusion became the order for the day, and the poor fled for protection to the cathedral, the abbey, and the churches. The city was placed under martial law. Wood fires were burnt in the streets in front of every door and inside the houses. "The sight," says the chronicler, "seemed very magnificent, to see so vast an extent of wall all illuminated; and if the city had been cured by this method, it had been cured in a most agreeable and joyful manner." The smell of burning sulphur concealed the effluvia of the dead, who by this time lay in heaps in the streets. Trenches were dug outside the walls, and there they were thrown in by the soldiery. Once there was a threat of riot amongst the

military, but this passed over quietly. Guards patrolled the walls to prevent the escape of the physicians, tenders of the sick, and others who might be of use; but the guards themselves took to flight, and what service the sick had was voluntary. "Thus proud Marseilles," says the chronicler, "which was but a few days past so flourishing, and which enjoyed the greatest plenty of everything that should make one happy, was now no other than the true image of Jerusalem in its desolation; and the plague which then began to rage had, in less than fifteen days, made here the most dismal theatre, by the most terrible and frightful ravages that ever were in any city of the world." The majority of the priests had fled, and their churches were shut up. But Father Milay, a Jesuit, thought he could never do too much; "he came and offered to take upon him the charge of commissary of the street of Lescale, and all the parts about it, a quarter which nobody durst take, by reason it was the seat where the plague raged the most violently, and the avenues leading to that place were barricaded by guards, to hinder any person from going in or out. They established this father, who, from the beginning of the contagion, was daily confessing the infected. In short, he did such acts of piety as were more than heroic. But the plague did not spare him long." The action of the bishop, too, was so greatly admired, that he was afterwards sainted. He did not confine himself to remaining prostrate at the altar. All his wealth was spent upon the poor, and the most hideous, the most abandoned, and the most miserable were those that he visited with the most ardency. On the 1st November, being the Feast of All Saints, the bishop went out of his palace in procession, followed by his canons and what priests remained, and appeared as a scape-goat sent out loaded with the sins of the people; and as if he had been a victim destined for the expiation of their sins, he marched with a halter about his neck, and a cross between

his arms, and barefooted; he celebrated mass in public, made a fine exhortation to the people, and an act of consecration of the city, to the Sacred Heart of Jesus, and finally announced that a holiday should be observed in honour of the same.

Whoso wishes to sup full of horrors may read further the official history of the plague at Marseilles; it will suffice here to mention that the disease abated in December, 1720, and with it the great European epidemic ceased.

Judging the treatment of this plague from a modern point of view, one may say that the people were probably right in attributing its spread to the poisoning of the wells and springs, though want of drainage rather than Hebrew malignity was the cause of this. Quarantine and other means of isolation were ineffectually carried out. The physicians were physicians of the cruet-stand, who thought by warm aromatics to cure a fever which, as we now know, once commenced, must take its course. Mixed with much absurdity and complex formality, we see one valuable idea running through all their measures for prevention; they invariably advised a plentiful supply and variety of fresh vegetables, and vegetable acid drinks. When we remember that a Queen of Henry VIII. had to send to the Continent for vegetables, and that in our own country at the present day they are only to be procured in and near the large towns, we may be disposed to give to the physicians a greater credit than they generally get. Out of a large number of their prescriptions which I have examined, there are, I am convinced, a few which we might with advantage use in the present day.

Approaching now to modern times, we find information both ample and accurate in the Transactions of the Epidemiological Society—perhaps the most diligent, most patient, and long-forbearing of all societies—and the Government Reports.

In the last year of last century plague was epidemic throughout lower Egypt and the entire extent of the northern coast of Africa, and in Tripoli, Tunis, Algiers, and Morocco the loss of life was enormous, for there locusts had caused famine, and famine favoured plague. In 1798, a French expeditionary army, thirty thousand strong, under Bonaparte, reached Alexandria in July, captured it, and then half the number marched upon Cairo, which was occupied by the end of the month. Six hundred died of the plague in Alexandria, and seven hundred in Cairo. It is to Assalini, chief physician in charge, and to Clot Bey, another French physician, we are chiefly indebted for descriptions of the disease suited to modern knowledge. Again, in 1801, a British force, seventeen thousand strong, under Sir Ralph Abercrombie, reached Aboukir Bay, ten miles from Alexandria, on the 1st March, and a detachment marched forthwith upon Cairo. This detachment suffered nothing from plague, but those that remained, being stationed where a frightful massacre of several thousand Turks by the French had taken place the year before, and where unfortunately the corpses had been insufficiently interred, the disease attacked four hundred, and there were one hundred and seventy-three fatal cases. In the same year there was also a large mortality in a force almost eight thousand strong, half European, half Sepoy, under Sir David Baird, which landed from India at Kossier, on the Red Sea. 1803 was very fatal to Constantinople, but for some years after plague disappeared. In 1812 it became widely diffused in the Levant, in the districts bordering the lower Danube, in Transylvania, in Asia Minor, in Armenia, and in Greece. In 1834 it spread up the shores of the Danube, but in 1839 it was again extinct in Europe, and remained so until 1853.

In India, the Pali plague, as it is termed, though differing somewhat from true Oriental or Egyptian plague, is never-

theless nearly allied to it. It broke out in Cutch and Kattywar, on the west coast, in 1815, and spread through the northern districts of Hindostan in 1817. At Gurhwal and Kumaon, in the Himalaya Mountains, there was a great mortality in 1836, and since then, up to the present time, the disease has never entirely disappeared. Preceded by four years of drought, it became epidemic in 1858, and again in 1873 and 1874, on the north coast of Africa, more especially Bengazi in Tripoli.

In Western Arabia (the Assyr country) plague commenced about the end of March, 1874, continued in a sporadic form until the middle of July, and in August became violently epidemic.

At Kerbela, west of the river Euphrates, it caused three hundred deaths in 1867. A military *cordon sanitaire* was drawn round the infected district, and fifteen days' quarantine imposed on all pilgrims. An attempt to force the cordon by two thousand pilgrims was not defeated until the party was fired upon. In the great marshes east of the Euphrates, with an estimated population of eighty thousand seven hundred, four thousand died of plague in April, May, and June of 1874.

In the district of Maku, Persian Kurdistan, there was an epidemic in 1863, and after extreme droughts in 1870 and 1871, the disease extended sporadically throughout Persia. From 1876 to 1878 it was again epidemic in the Persian province of Ghilan, south-west of the Caspian, and at Astrabad, south-east of that sea.

Finally, it is important to note the admission of the Russian Government, that, in 1877, there were throughout Russia two hundred and forty-one cases of what is termed Siberian plague, with a mortality of twenty-one per cent.

There is a theory in Russia that every time their army invades Turkey, it brings back with it the plague; and the

story goes that in November last, towards the end of the month, a detachment of Cossacks which had formed a part of the army of the Caucasus, returned to its quarters, Vetlianka on the Volga, in the district of Jenotajevsk, province of Astrakhan, where, soon after their arrival, fever broke out. But in the Caucasus, and in fact in all the camps of both opposing armies wherever placed, though a destructive fever had raged, that fever was certainly not plague, but typhus, and typhus therefore it was thought to be in Astrakhan. Whatever the source, and whatever the fever, on the 9th December, some of the inhabitants were seized with violent headache, pains in the limbs, fever, and swelling of the glands; purple spots soon appeared, and after three or four days some died. The medical authorities of St. Petersburg declared that it was only typhus. But during the first two days of the new year, out of one hundred and ninty-five cases, one hundred and forty-three proved fatal. A panic in the villages ensued, and a large number of the population, both civil and military, fled, in all probability carrying the infection with them. The Governors of Astrakhan and Saratov placed the infected district under martial law, and a military *cordon sanitaire* surrounded it, in order to prevent all communication between sick and healthy. Nevertheless, on the 25th January, a Commissioner from St. Petersburg, Dr. Krassovsky, arrived in Vetlianka, and telegraphed to head quarters that the disease was "galloping typhus,"—galloping, indeed, for there were two hundred and seventy-three deaths, including all but one of the attendant physicians, and more than three hundred lay sick. Such a report, and similar ones of a later date, all persistently denying existence of plague, may well remind us of the infatuation and incompetence of Surgeon Guerera of Marseilles. But Russian physicians know well what they are about, and their activity in science is as great as in any other European country. While no one ever heard of scien-

tific work by a Turk, Russia abounds in scientific periodicals containing the most recent information and new research. The reports were based upon political rather than medical considerations; plague it must not be called, though plague precautions were to be thoroughly enforced. Meantime, the disease, in spite of all quarantine, scattered over the whole of the river-side districts on the right bank of the Volga, from Astrakhan to Tsaritzyn, and within the borders of the province of Saratov; and on the 25th February a case was reported in St. Petersburg. By the 8th March plague had so much abated in Vetlianka and its neighbourhood, that few cases remained, and the military commenced, and still continue, burning down the houses and fishing stations of the infected district.

There can be little doubt that Persia was the true source of infection. There is extensive communication by the Caspian Sea between the towns of Reshd and Astrabad and the Russian villages on its western shore. Now, these were well known to be infected with what is probably the Pali or Indian form of plague, and to seek further for a source appears useless.

What have the other nations done under these circumstances? France has ordered that all suspected vessels are to undergo strict quarantine for five to ten days at the Mediterranean ports, and all vessels with actual disease on board, a quarantine of ten to fifteen days after complete disinfection. In channel ports quarantine is to last from three to five days.

Germany and Austro-Hungary have enforced a strict quarantine on the Russian frontier of twenty days' duration, and certain articles of merchandise are altogether prohibited. The North Railway has even determined to stop direct traffic between Warsaw and Vienna by way of Granitza. Commissioners from both countries have been sent to investigate the infected districts.

On the 15th March two medical gentlemen, nominated by the College of Physicians, London, left England for purposes of investigation. It is said that the Government pays their expenses, gives them ten guineas a day, and has ensured their lives for a considerable sum. Vessels from the Baltic to our eastern ports are required to undergo quarantine.

Had not my paper already reached such a length, I should have liked to have discussed the value of quarantine with some detail. For the necessity of its existence is denied by some, who hold that it is an antiquated precaution needlessly interfering with the routine of trade, costly, never properly carried out, and effecting at the best no more than what, by the simple plan of strict isolation of the sick as they appear, in hospital or at home, our modern local sanitary boards, with their efficient staff, are capable of.

For those who are not sanitary authorities it will be enough to remember the lesson which is applicable, not only for protection against plague, but also against those other fevers with which we must all be more or less familiar, namely, that the most effectual means for the protection of a community against the propagation of an epidemic are the isolation of the sick, the destruction by fire of their clothes, or at the least their thorough disinfection by dry heat, and the whitewashing with lime, and free ventilation of the rooms which have been inhabited by the sick. Contagion cannot travel far without being carried; it is a familiar proverb in the East, even of plague, that it cannot go up stairs. It can, however, go down stairs, and we would do well to look to the crowded cellars of our town.

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EXTRACTED FROM U.S. GEOL. AND GEOG. SURVEY OF THE TERRITORIES.

A DESCRIPTION OF A DAKOTAN CALENDAR, WITH A FEW ETHNOGRAPHICAL AND OTHER NOTES ON THE DAKOTAS, OR SIOUX INDIANS, AND THEIR TERRITORY.

By ALFRED MORGAN.

In the chronological chart which I bring under your notice this evening, it is said we have the only known instance in which an attempt has been made by the North American Aborigines to record the flight of time in its annual periods, or indeed to take note of it in any way whatever, as it pursues its inexorable course. The chart is remarkable for its simple accuracy, and in this respect it presents a strong contrast to those other Indian records with which we are familiar, and in which a certain bragging arrogance is nearly always conspicuous. It is a simple register of the passage of year after year of the Dakotan history, and no attempt at embellishment has been made, nor have the compilers attempted to glorify either nation, tribe, or individual.

As readers of books of travel among the North American Indians will be aware, it is an old custom among the tribes to depict in the usual hieroglyphs, or picture characters, known as "Indian writing," upon buffalo robes, or on strips of bark, the story of the most notable events in the tribal history; or to delineate those deeds of prowess and daring which constitute the claim of their most illustrious chiefs to the admiration of posterity. And travellers have naturally desired, whenever possible, to bring home with them one or more of these "painted robes" as mementos of their sojourn among the wig-wams of the "Red-Man." If we are to credit the report,

however, many of these prized garments are spurious, and are but poor copies of the originals. The laws of supply and demand, with which we are so familiar in Liverpool, are not altogether unapprehended by the untutored savage—Nature's gentleman—who roams the trackless prairie, and he has learnt to keep on hand, for sale to unsuspecting travellers, robes which he has made for the purpose. While, among our "kin beyond sea," enterprising traders have been found who, supplying both robes and paint, have employed "Agency Indians" to decorate them to order. Many genuine records have been brought home, however, by explorers, and have been described in works of travel, and as we peruse such journals by our firesides, we almost feel as though we possessed a practical knowledge of the countries they have visited.

It was while reading one of the many interesting volumes that have been published by the Hayden Survey that I made a note of the "Dakotan Calendar," as being a suitable subject on which to write a short paper for one of our miscellaneous evenings; and, as one so often experiences, the subject grew into larger proportions the more it was thought about, and it now comes before the Society as the topic of a longer paper, which I hope will not prove uninteresting.

Before proceeding to describe the Calendar, I would indicate in a few words the physical and economical features of the Dakotan territory. That portion lying to the east and north of the Missouri is generally quite sterile, consisting of a prairie of great extent, utterly devoid of trees or shrubs. The soil is loose and sandy, the grass thin, that variety known as buffalo-grass being the most abundant. Along the borders of the streams, and in some parts, there is good grazing ground. To the west and south of the Missouri River the prairie is more rolling, and

has many large streams. Along the margins of these, timber is abundant. The most fertile region is along the eastern base of the Black Hills, where there is beautiful scenery, and a very fertile country of great extent. Buffalo are abundant. Near the source of White River are situated the celebrated "Mauvaises Terres," or Bad Lands, so remarkable for unique scenery and for the extensive series of remains of an extinct vertebrata, which are included in its strata. This portion of the territory is about one hundred and fifty miles in length, by sixty miles in width. Dr. Hayden, in speaking of this wonderful region, says:—"Along White River, for sixty miles in length and fifteen to twenty in breadth, the country presents the appearance in the distance of one vast city, and but little imagination is required to see immense public edifices, towers, churches, etc., with people on their summits. What tends to make the illusion more perfect is, that the mountain sheep (*Ovis montana*), sometimes alone and sometimes in small bands, are seen on the tops of these towers, which are several hundred feet high, and entirely inaccessible to the approach of man. Here they remain in security, rolling their large horns from side to side and casting suspicious glances at the traveller below. It is somewhat strange that this animal should prefer the most rugged and inaccessible places, where scarcely a spear of grass is seen, and no shrubs, but here and there a solitary bunch of stunted sage. A few small grassy spots, like oases, are found in this region, low down at the base of these lofty towers and ridges, to which the mountain sheep descend early in the morning to feed." * The rugged nature of the country renders travelling very difficult, and water is scarce. The Indian winds his devious way along intricate defiles, and pitches his tent in the neighbourhood of one of the scattered springs, in quest of game; but the white man is tempted into the region to

* Hayden, *Indian Tribes of the Missouri Valley*, p. 366.

examine, not only its curious phenomena of denudation, which have produced its characteristic scenery, but also to study the organic remains which abound in the country, and have long awakened the superstitious curiosity of the native tribes and puzzled the practical-minded voyageurs. The remains consist of vertebrata, and have been described by Professor Joseph Leidy in the Proceedings of the American Academy of Natural Sciences, Philadelphia, and in the valuable publications of the United States Geological and Geographical Survey by such eminent palæontologists as Cope, Newberry, Hayden, etc. The superficial strata of the country consist of light-coloured clays, grits, and marls, more or less indurated and worn into fantastic outlines by sub-aerial agents. All the shells that have been found are of land and fresh-water species, and the region was probably a vast inland lake of the Miocene era.

The remainder of the Dakotan territory may be described as of a sandy nature, with prairie, occasional lakes, and many fertile valleys, and abundant buffalo, though this fine animal is becoming less numerous every year. Elk and antelope roam in large herds, and several fruits and succulent roots are found. The prairie turnip (*Psoralea esculenta*), the wild artichoke (*Helianthus tuberosus*), the Dakota pea (*Apios tuberosa*), the plum (*Prunus Americana*), the choke-cherry (*Prunus Virginiana*), and the service-berry (*Amelanchier Canadensis*) are the most important. With regard to the Dakota pea, as it is called, the tuberous roots of which form the edible portion, it is a very curious fact that the Indians do not gather it for themselves, but resort to a system of robbery to obtain it. A species of field-mouse, which is very abundant in the locality, collects large stores for its winter use, and the squaws, on whom it devolves to collect the supplies of this vegetable, organise a system of pillage of the nests of this provident little animal, and often get as much

as half-a-bushel from a single nest, and, when cooked with buffalo-meat, are said to form a very palatable dish.

Besides the animals mentioned, the territory is inhabited by several kinds of foxes, beavers, otters, grizzly bears, badgers, skunks, porcupines, rabbits, musk-rats, a few panthers, and the singular prairie-dog, whose wonderful subterranean burrowings have given rise to many fabulous stories.

Terrible snow-storms sweep over the country. In the words of Dr. Hayden, "In winter travellers are sometimes frozen to death in crossing these prairies; for when storms occur it is often impossible to travel, the sun is invisible, and all objects are hidden at the distance of fifty to one hundred paces by the particles of snow that are whirled through the air by the wind. This is called by the Canadian voyageurs "*pouderie*," and, when occurring in extreme cold weather, leaves but two alternatives to the traveller, to ramble on at hazard, in the hope of keeping himself warm by walking or getting to timber, or to lie down and let the snow blow over him, remaining in the temporary grave until the atmosphere becomes clear, and his course can be determined by the sun or stars."

In comparatively recent times the Dakotas held the immense region bounded by the Rocky Mountains on the west, the Athabascan tribes in British America on the north, and the present state of Kansas on the south, and extending in the east beyond the Mississippi river they came into contact with the Algonquins. One division of the nation, the Winnebago, settled upon the shores of Lake Michigan; and another, the Quappas, or Arkansas, penetrated to Ohio River, but were driven back by the Illinois. The state of Arkansas is named after them. Their present territory is about the size of the state of Michigan. The United States government has had a great deal of trouble

with several formidable bands of predatory Indians, of which Sitting Bull is the chief leader, and which refuse to recognise certain treaties that have been framed from time to time, and continue to hunt and rob after the manner of their forefathers. The numerical strength of the recusant faction may be set down at about six thousand, but in times of discontent it becomes much larger, when, ignoring treaties and obligations, the Dakotas as a nation roam defiantly over a region estimated to be four hundred and seventy thousand square miles in extent, or, in other words, equal to the united areas of France, Spain, Portugal, Belgium, Holland, and Greece.

We can readily understand that the United States Army encounters great difficulty in its operations against these tribes, arising not only from the magnitude of the district, but also from its physical character, and we may be quite sure that the hostile bands are generally only to be met with in those localities which afford them the greatest defensive advantages.

The expedition of General Custer, 1874, will be remembered by many, and the papers, only a few months ago, frequently reported skirmishes at Black Hills, which are the most important mountains in the territory.

The word Dakota means "leagued," or "allied." Dr. J. Hammond Trumbull gives the meaning as "associated as comrades." The roots are "*daki*," clan or band, and "*cota*," friend. These radical terms are known to exist in all the dialects of the Sioux language.

Colonel Mallery, however, says that the Dakotas he has examined upon the subject always insisted that the meaning of the national appellation was "men," or "Indian men," as distinguished from white men. This assumption has been noticed among other tribes of the aborigines. *Real men*, "Onkwi honwe" of the Hurons and Iroquois, "Ren-

nappe," "Lenni," "Illiniwek," "Irini," and "Nethowuck," names of Algonquin tribes, etc., all have that meaning.

The title Sioux is indignantly repudiated by the nation. It is either the last or the two last syllables, according to pronunciation, of "Nadowesioux," which is the French plural form of "Nadowessi," *enemy* or *hated foe*. The Chippeways called the Iroquois, "Nadowi," *adder*, plural "Nadowek." The French gave the word its plural form, and the voyageurs and trappers cut it down to "Sioux." The Dakotas have a tradition that they migrated from the "great water," and Colonel Mallery says that their language more nearly approaches the Mongoloid dialects than that of any other of the American Indians.

The Rev. Stephen R. Riggs, whose valuable "Dakotan Grammar" was published as one of the quarto volumes of the Smithsonian Institution, says, of the religion of the people, that they have indeed "gods many," peopling both the visible and invisible worlds with mysterious beings. "The Dakotan has his god of the north, and god of the south, his god of the woods, and god of the prairie, his god of the air, and god of the waters." . . . "No one can witness their religious ceremonies without being deeply impressed with the fact that what Paul said of the Athenians is true, to a very great extent, of the Dakotas,—"κατὰ πάντα ὡς δεισιδαιμονεστέρού,—*In all things very worshipful.*"

The more important of the existing tribes, or organised bands, into which the nation is now divided, are as follows:—

1 Yanktonai......"At the end."
2 Sihasapa ......"Black feet."
3 Ohinonpa ......"Two kettle."
4 Itazipcho ......"Without bow."*

* This division is generally designated, in its French form, "Sans arc."

5 Minneconjou...“Reeds around water.”
6 Sichangu ......“Burnt hip.”
7 Santee ....“Men among leaves.”
8 Ogallalla ......“Always moving.”
9 Uncapapa......“Those who shout or yell.”

This last group comprises the most warlike and powerful warriors of the tribe. Sitting Bull is its most prominent member, though not its chief. The latter individual rejoices in the name of Thunder-hawk. The worthy whose cognomen of Sitting Bull has appeared all over the world in newspaper accounts of Indian disturbances, was originally known as Buffalo by the tribe, but in order to distinguish his totem from that of all the other bisons or buffaloes, and to avoid confusion among their armorial bearings, he blazons his upon its haunches in the heraldic position of *sejant.*

The number of the Dakota nation is estimated at about fifty thousand at the present time, but at the beginning of the century they were far more numerous. Their decrease has been very rapid. Whisky, smallpox, and other gifts of civilisation have done their work, and several once powerful tribes are now only represented by miserable remnants. As an illustration, I may refer to the Quappas, once a mighty horde which, migrating from the Rocky Mountains, led the van of irruption eastward, and forced its way through hundreds of miles of hostile territory; though now this formerly great tribe is reduced in number to about two hundred individuals. Colonel Mallery computes that at the time our calendar commences the Dakota nation numbered at least a quarter of a million individuals.

The series of years delineated on the chart commences with the winter of A.D. 1799–1800. The calendar was copied by Lieut. H. T. Reed, of the United States army, and

by him communicated to Brevet Lieut.-Colonel Garrick Mallery, his commanding officer, who describes it in a most interesting paper, contained in the *Bulletin of the United States Geological and Geographical Survey of the Territories*, vol. iii., 1877. After exhibiting Lieut. Reed's drawing to the military and civil officers of the Department of War and of the Interior, at Washington, it appeared that those who, from long service on expeditions and surveys, or from special study of American ethnology, were most familiar with the Indian tribes, had never heard of this or any other similar attempt having been made among them to establish a chronological system.

The painted robes I have referred to, as being commonly found among the Indian peoples, are not the only records that exist. The Algonquins, for instance, are said to use strings of beads, fashioned from shells of different colours, called *wampum*, to note events; but these devices are mnemonic only and not symbolic. The Pueblos figured histories on tablets of wood. The Aztecs and Toltecs have left elaborate specimens of their narrative picture-writing.

In the Missouri country, Dr. F. V. Hayden observed immense expanses of soft cretaceous rocks which are in many places covered with hieroglyphics. These rocks present mural surfaces, and are very conspicuous. Dr. Hayden points out, in proof of the antiquity of the inscriptions, that they are frequently to be found in positions that are totally inaccessible to the Indians of the present day, and says that he thinks as much as fifty feet in depth of rock has been washed away by the turbulent Missouri since they were written. None of the Indians now living in the country know anything about them, but it is significant that the Dakotan name for one of the creeks, where the hieroglyphical characters are very abundant, signifies "the creek where the dead have worked." *

* *Report U.S. Geog. Survey of the Terr.*, vol. i., p. 47. Washington, 1869.

The inscriptions that are so abundantly found upon the walls of the ancient dwellings of Colorado, etc., suggest many important questions with regard to the mysterious people who built the Cliff-houses. The fineness of their building, and the perfection to which they had brought the fictile art, as is so abundantly testified by the remains of their industry, seem to indicate a very high state of civilisation. Enquiry is being vigorously carried on, and, though sufficient time has not yet elapsed to enable American ethnologists to put forward a general theory on the subject, many are inclined to accept the conclusion that the "aboriginal" races must be classed among the Turanian or Mongolian family.

The robe from which Lieutenant Reed made his drawing belonged to Lone Dog, an aged Indian of the Yanktonai tribe of the Dakotas, and its genuineness was attested by many Indians with whom Lieutenant Reed spoke while in Dakota Territory. Investigations were carefully made, and resulted in the following account:—Lone Dog had ever since his youth been charged with the special duty of deciding upon some event or circumstance which should distinguish each year as it passed, and, when such decision had been made, he marked it by its appropriate symbol upon the buffalo robe kept for that purpose; then calling together a number of the Dakota nation, without regard to tribe, he made known to them the sign for the year, or "year totem," and explained what it represented. This was done annually and privately, but it is understood that the robe was at other times exhibited to the Indians of the nation, who were thus taught the meaning and use of the signs that designated the several years, in order that, at the death of the official chronologer, the knowledge might not be lost.

Although Lone Dog is described as an aged Indian, it is not

supposed that he was of sufficient age in the year 1800 to enter upon this duty. Either there was a predecessor from whom he received the earlier record, or from whom he obtained copies of it, or, his work being undertaken at a later date than 1800, he gathered up the traditions of the tribe and "worked back" as far as he could. The disturbances in the Indian country have prevented the prosecution of enquiries as to the existence of earlier records, if there should be any. And the question naturally suggests itself as we study this one, whether intercourse with whites did not first give the Dakotas an idea of dates and of passing time, and awaken in them a sense of the want of a chronology. The fact that the date at which it commences so nearly coincides with the beginning of our century may be due to such intercourse, or it may be a coincidence merely. Colonel Mallery points out that the starting point is not any given era such as our A.D., or the Hegira, etc., and which is the fundamental idea upon which all existing chronologies are built up. The earliest symbol, Fig. 1, in the centre of the calendar, merely represents the killing of a small number of Dakotas by their enemies, an event of frequent occurrence, but neither so important nor so interesting as many others of the seventy-one figures rendered in the series, more than one of which might very suitably have been selected as a notable fixed point from which to reckon both before and after. Instead, however, of following the usual plan of civilised nations, which would naturally be the one suggested by traders or missionaries, if such were the originators of the calendar, the one actually adopted, to individualise each year by a special symbol, or totem, seems rather to indicate the advent of an idea, and shows more of the scientific spirit to exist among this section of the aboriginal tribes than was supposed to be the case.

This symbolic record being understood by all, could be easily referred to, and conveniently used with sufficient

accuracy for all ordinary purposes. The arrangement is a very simple one. Commencing in the centre of the calendar, the various signs follow each other in their regular sequence; and, though no numbers are used in the original chart, the totems may be readily counted either backwards or forwards from any given point. While such symbols as those which register the first appearance of smallpox, or the first capture of wild horses, denote really important eras in the national history, they at the same time afford definite data, and answer all the purposes of our A.D. and A.M.

The calendar may be thus briefly described:—

FIG. 1.—Thirty Dakotas were killed by Crow Indians. The year is ascertained to be 1800 A.D., or, more accurately, the winter of 1799. The Dakotas count their years by winters, and naturally so, for in their high latitudes the winter lasts half the year. They say a man is so many "snows" old. They have no division of time into any shorter period than the lunar month. They have names for twelve only of the annual lunar periods, *e.g.*, the February moon is called the "raccoon moon," March the "sore-eye moon," April the "geese begin to lay eggs" moon. As the appearance of raccoons after hibernation, the causes that produce inflamed eyes, and the oviposition of geese vary with the meteorological character of each year, and the twelve lunations do not bring back the periods to the point from which the counting commenced, there is often warm discussion in the Sioux tents towards the end of the winter as to the correct current date.

The symbol consists of thirty parallel black lines in three columns. In the chart such black lines always denote the death of Dakotas at the hands of their enemies.

FIG. 2. 1801.—The smallpox broke out in the nation. An Indian is depicted covered with red blotches.

FIG. 3. 1802.—Dakotas stole horses with shoes on; *i.e.*, stole them from the whites, or from Indians who had previously stolen them. Symbol, a horse-shoe.

FIG. 4. 1803.—They stole some "curly horses" from the Crows. Some of this breed of horses are still to be found on the plains; the hair grows upon them in woolly tufts, like a negro's pile.

FIG. 5. 1804.—The Dakotas had a calumet dance, and then went to war. The symbol is a long pipe-stem, ornamented with feathers and streamers. The feathers are represented as white ones with black tips, probably the tail-feathers of the golden eagle (*Aquila chrysaëtos*). The streamers were probably coloured strips of hide or bark. The word calumet is a corruption of the French *chalumeau*, and the pipe, among all the Mississippi tribes, is the symbol of peace. Capt. Carver,* one of the pioneers of exploration, in the record of his travels, puzzles over the etymology of the word calumet (that "honest captain of provincial troops" not understanding French), and reports such pipes as were then used as about four feet long, bowl of red marble, stem of light wood, curiously painted and covered with hieroglyphics, and adorned with feathers. Each nation has a different style of pipe decoration, and the article in question is brought out on such important occasions as the introduction of a treaty, and serves as a flag of truce to white people. The event commemorated was a grand council of the various tribes of the nation for the settlement of all internal feuds and difficulties among them, so that all might unite against the common enemy.

* *Three Years' Travels through the Interior Parts of North America.* Philadelphia, 1796.

FIG. 6. 1805.—The Crows killed eight Dakotas.

FIG. 7. 1806.—A Dakota killed an Arickaree (this name is generally abbreviated into "Ree") as he was about to shoot an eagle. The Arickarees are a branch of the Pawnee family, and though now reduced to about a thousand in number, were, at the time spoken of, a powerful nation, consisting of ten large bands.

FIG. 8. 1807.—Red Coat, a chief, was killed. The figure shows the red coat pierced by two arrows, with blood dropping from the wounds.

FIG. 9. 1808.—The Dakota who killed the Ree (Fig. 7) was himself killed by the Rees. He is depicted as running, and shot with two arrows, his blood dropping. It is noteworthy that though war had been then raging between the Dakotas and several other tribes, it is not referred to in the chart. The predominant idea evidently being to record some one peculiar event in each year, not to give a continuous history. It would have been difficult to have described in a graphic way the many battles, treaties, horse-stealings, and hunts of the year, and consequently the artist selected those events possessing the strongest individuality.

FIG. 10. 1809.—A chief, Little Beaver, set fire to a trading-store, and was killed.

FIG. 11. 1810.—Black Stone made medicine, to bring the Buffalo within reach. Sir William Blackstone has been accused of "making law" in his Commentaries, but it is not intended to bring a similar accusation against his Indian namesake, for innovation in the "regular practice" of medicine. As you all know, the "medicine men" have no connection with therapeutics, feel no pulses, administer no drugs, or, if sometimes they direct the internal or external use of a secret preparation, it is as a part of, and with a reliance upon,

superstitious ceremonies, in which they put the "charm of woven paces and of waving hands," utter wild cries, and muddle in abominations, until they work themselves into an epileptic condition. Their incantations have not only for their object the driving away of disease, but also to secure success in war, to bring the buffalo herds within reach, and a variety of other purposes. Colonel Mallery considers their rites to be clearly those of Shamanism, and as indicative of the connection of the Sioux tribes with those of Northern Asia. The symbol represents the worthy doctor holding a buffalo-head above his own.

FIG. 12. 1811.—The Dakotas fought a battle with the Gros Ventres and killed a great many. Symbol, a circle, enclosing three round objects designed to represent heads. The Sioux appear to be inveterate cut-throats, and, in the sign language of the plains, they are denoted by drawing a hand across the throat, signifying that they cut the throats of their enemies. The Dakotan method of counting is by means of the fingers, as it is commonly practised by savage tribes, but with a peculiarity of their own. When they have gone over the digital series, a finger is turned down to represent *ten*, or *one ten;* for twenty, another finger is turned down, and so on to a hundred. Colonel Mallery derives their term for a hundred, "opawinge," from "pawinga," *to go around in circles.* The figure of the circle is never used to denote less than a hundred.

FIG. 13. 1812.—Wild horses were first run and caught by the Dakotas. The symbol is a lasso. The date is of interest, as showing the time at which the herds of prairie horses, descended from those introduced by the Spaniards into Mexico, Texas, etc., had multiplied so as to extend into far northern regions.

FIG. 14. 1813.—The whooping-cough was very prevalent and fatal. The sign is ludicrously suggestive of violent cough.

FIG. 15. 1814.—A Dakota killed an Arapapo in his lodge. The symbol represents a tomahawk transfixed in the victim's skull.

FIG. 16. 1815. The Sansarcs made the first attempt at a dirt lodge. Crow Feather was their chief, and his totem is represented at the top.

FIG. 17. 1816.—Great plenty of buffalo meat. The symbol represents the side of an animal, hung up to dry.

FIG. 18. 1817.—La Trombois, a Canadian, built a store with dry timber. The dryness of the wood is symbolised by the dead tree.

FIG. 19. 1818.—The measles broke out, and many died. The figures on the original drawing exhibit a marked difference in the character of the smallpox and the measles blotches.

FIG. 20. 1819.—Another trading-store was built.

FIG. 21. 1820.—A trader, La Conte, gave Two Arrow a war dress for his bravery. The trader is symbolised by the store, and the long strip represents the cloth for the dress.

FIG. 22. 1821.—This year a comet and its attendant meteoric display were observed.

FIG. 23. 1822.—The erection of a third trading-house was the most remarkable event of the year.

FIG. 24. 1823.—White soldiers first made their appearance in the region. One of these is represented clothed, wearing a hat, and firing a carbine. He is standing near a tent or barracks.

FIG. 25. 1824.—Swan, chief of the Two Kettle tribe, had all his horses killed.

FIG. 26. 1825.—There was a great and disastrous flood of the Missouri, and several Dakotas were drowned.

FIG. 27. 1826.—An Indian died of the dropsy. The conjecture is hazarded that the swelling of the patient was such as to increase his bulk to the dimensions of the space indicated by the black line.

FIG. 28. 1827.—Dead Arm was stabbed with a dirk by a Mandan.

FIG. 29. 1828.—A white man, named Shardran, built a lodge.

FIG. 30. 1829.—Bad Spike killed another Indian with an arrow.

FIG. 31. 1830.—Bloody battle with the Crows, of whom many were killed.

FIG. 32. 1831.—Le Beau, a white man, killed another named Kernel.

FIG. 33. 1832.—Lone Horn had his dog killed, so the interpreter rendered this symbol, but it is not intelligible.

FIG. 34. 1833.—Another meteoric display is recorded.

FIG. 35. 1834.—A chief named Medicine-hide was killed.

FIG. 36. 1835.—Lame Deer is said to have shot a Crow Indian with an arrow, and, after drawing it out of his body, to have shot him again with the same weapon. A circumstance giving rise, no doubt, to much remark at that period.

FIG. 37. 1836.—This year buffalo were again very plentiful. See Fig. 17.

FIG. 38. 1837.—An attempt is here made to represent an elk. A great hunt was organised, and about a hundred elk were said to have been killed.

FIG. 39. 1838.—A dirt lodge was built for Iron Horn. His totem does not appear. Perhaps Lone Dog found his artistic power unable to draw an iron horn, though equal to a crow's feather.

FIG. 40. 1839.—The Dakotas killed an entire village of Snake Indians.

FIG. 41. 1840.—The Dakotas made peace with the Cheyennes.

FIG. 42. 1841.—Feather in the Ear stole thirty spotted ponies.

FIG. 43. 1842.—One Feather raised a large war party against the Crows. He holds the calumet pipe.

FIG. 44. 1843.—The Sansarcs made medicine to bring the buffalo. The symbol represents the medicine-tent and buffalo head.

FIG. 45. 1844.—The Minneconjous built a pine fort.

FIG. 46. 1845.—Another year of plenty. The buffalo meat is represented as suspended on poles on the branches of trees.

FIG. 47. 1846.—Broken Leg died.

FIG. 48. 1847.—Two Man was killed.

FIG. 49. 1848.—Humpback was killed.

FIG. 50. 1849.—The Crows stole a large number of horses. The prints of the horses' hoofs are represented, with a circular enclosure.

FIG. 51. 1850.—This symbol is a most remarkable one. The interpreter gave its meaning as being a record of a buffalo-cow having been killed in this year which was found to contain the body of an old squaw.

Professor J. W. Powell says that the Sioux have long believed in the appearance from time to time of a monstrous animal that swallows human beings. This superstitious idea probably originated in the discovery of the remains of such gigantic animals as the Mastodon, which have already been referred to, and as the buffalo is the largest quadruped with which the Dakotas are familiar, they imagined the existence of a legendary monster of the bison type, and in this conjecture, apart from its anthropophagous propensity, they were

not far wrong, as the horns of the fossil *Bison latifrons* are ten feet in length. The mysterious disappearance of a squaw this year was popularly accounted for by supposing that this dreadful monster had made his appearance and swallowed her.

Fig. 52. 1851.—Peace was established with the Crows. The pipe of peace and a friendly attitude are depicted.

Fig. 53. 1852.—The Nez Percés came to Lone Horn's lodge at night. So it was interpreted; but the cause of the nocturnal visit was not remembered. The name, Nez Percés, is remarkable and somewhat of a misnomer, as they do not pierce their noses, nor have they ever been known to do so.

Fig. 54. 1853.—Spanish blankets were first brought to the Dakotas. The drawing represents a trader holding one of these striped blankets, and, evidently, endeavouring to find a purchaser.

Fig. 55. 1854.—Brave Bear was killed. This warrior had, apparently, invested in the new style of blanket.

Fig. 56. 1855.—General Harvey made a treaty of peace with several Dakotan tribes this year.

Fig. 57. 1856.—Four Horn was elevated to the rank of Medicine-man.

Fig. 58. 1857.—The Dakotas killed a Crow squaw. The squaws appear to have worn their blankets with the stripes placed horizontally, while the men adopted the vertical position.

Fig. 59. 1858.—Lone Horn made buffalo medicine; those sagacious quadrupeds being absent without leave.

Fig. 60. 1859.—Big Crow, a Sioux chief, was killed by the Crows. The Crow, transfixed by an arrow, is drawn so as to give quite a heraldic appearance to the totem. Colonel Mallery suggests that, to complete Big Crow's signet ring, his engraver need only have added in a

scroll, by way of a motto, the familiar line of Juvenal, "*dat veniam corvis.*"

FIG. 61. 1860.—The Elk-that-hollas-while-walking made buffalo medicine.

FIG. 62. 1861.—Buffalo were so numerous that their tracks were observed close to the tepees.

FIG. 63. 1862.—Red Feather was killed.

FIG. 64. 1863.—Eight Sioux were killed.

FIG. 65. 1864.—The Dakotas killed four Crows. The heads are coloured red, to distinguish them from the similar objects in Fig. 26.

FIG. 66. 1865.—Many horses died from want of grass.

FIG. 67. 1866.—Swan died. This gentleman is dressed in a Spanish blanket, but his totem is not very intelligible.

FIG. 68. 1867.—The flag here represented denotes the visit of the U.S. Peace Commissioners, who held several councils with the chiefs of the various tribes, which resulted in the Sioux Treaty of 1868.

FIG. 69. 1868.—This year witnessed the introduction of Texas cattle into the country of the Dakotas.

FIG. 70. 1869.—An eclipse of the sun was observed; the Sioux territory being situated along the line of totality.

FIG. 71. 1870.—The Uncapapas had a battle with the Crows. Fourteen Dakotas were killed. The circle represents a fort. This is shown as nearly surrounded by the enemy, while bullets are flying around. This is the first indication which the Calendar affords of the use of firearms, though it is probable the Dakotas had for some years previously been acquainted with such weapons.

Thus ended the series of symbols upon this singular chart at the time it was copied; and if the record has been con-

tinued, it will be interesting to observe what events have been regarded as most characteristic of subsequent years. Measures have been taken to secure this information, which, when obtained, will no doubt be published. We have seen that the calendar is not a narrative of events so much as a record of time. The year was the important subject which it was designed to note; and, considering the general obliviousness of uncivilised races with regard to time, it affords an interesting instance of an attempt having been made, which was before unsuspected, among the nomadic tribes of North America to establish a chronological system.

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Grammar and Dictionary of the Dakota Language. Rev. S. R. Riggs, A.M. (Smithsonian Contributions, vol. iv. Washington, 1852.)

Also several scattered notices contained in the publications of the War Department of the United States, and in the Reports of the United States Geological and Geographical Survey of the Territories.

ON THE ARRANGEMENT OF THE SHELLS IN THE GENUS NASSA.

By Mr. F. P. MARRAT.

The collection which has afforded materials for the following remarks closely fills ten large drawers; it includes about three hundred named species, one hundred named varieties, and intermediate forms, many of which have fully an average claim to be regarded as new species, illustrated by more than two thousand specimens.

My object in gathering together the large series of specimens laid on the table before you, was to test the validity of the supposed species, and to confirm either the old system of their being fixed and well-defined, or the comparatively recently-proposed theory that all species are mere varieties without any definite or fixed limits. The first step that suggested itself to my mind, was to follow the plan almost universally adopted by conchologists, viz., that of arranging the varieties of each species under their respective names, but when I came to compare such lines of species and varieties, they were found to pass one into another, and many of them in such a way that I found it a task of considerable difficulty to find and pick them out again. This, of course, was leading me into the groove of variation, and as the number of varieties under examination increased, the more perplexing this difficulty of separation became, until at least two-thirds of the shells ranking as species seemed to be inextricably blended with one another. As each successive series of varieties was obtained and compared, the more the species showed a tendency to run into others that had hitherto appeared to be distinct, until, having

passed the centre, or examined more than one-half of the so-called species, fusion was fast becoming the rule, and not the exception to the rule. My next difficulty was how to account for these constant changes, and to enquire for any characters that had sufficient permanence to be used for separation, or, in other words, could a skeleton be found to build the whole of this variable mass of materials upon. It struck me that all natural objects were best studied by commencing with the simplest forms, consequently I chose the smooth unsculptured shells as the foundation, and very soon found that external sculpture could be traced from a mere coronation on the edge of the whorls, to its elongation into a kind of rudimentary rib; which in other specimens became longer and longer until the rib was formed across the whorl, and the process could be seen in all its stages of development.*

The most gradual changes of external ornamentation, from the smoothest or almost glassy forms, to the extreme of sculptured variation, could be traced with the utmost precision. Every shade of difference in each of the characters, such as coronation, ribbing, sulcation, cancellation, and papillose external sculpture, occurs in every conceivable stage of development, from the simplest to the most complex.

The following are the chief characters employed in the discrimination of shells, designated species :—

1st. Form.
2nd. Colour.
3rd. Sculpture.
4th. Canal open or closed.
5th. Length of spire compared with body whorl.
6th. Outer lip, either thickened, thin, or spinous.
7th. Interior plain or grooved.
8th. Columella smooth, plicate, granular, or callous.

These are the principal distinctions used in the most

expensive and best monograph on this genus, viz., Reeve's *Conchologia Iconica*, vol. 8, Nassa, Lam. All other writers on shells use either these terms or similar ones, and they have been, and still are believed to be, sufficient for practical purposes. If we confine our examination to the identical specimens figured and described, *i.e.*, to the type specimens, then the terms used are correct; but if we study the shells as they occur, with their innumerable varieties, then those terms become totally inconclusive.

The subject I am about to bring under your notice this evening is of grave importance, and will, perhaps, in the future involve the absolute necessity of changing the whole system of conchological arrangement, and adopting some other mode of classification. We cannot close our eyes to the fact that a more minute and careful examination is constantly revealing new and strange combinations of characters totally at variance with our preconceived ideas. Much has been done in the way of collecting, and we may look for a large influx of knowledge from the materials brought home in the *Challenger*. Not only the life-history of the Mollusc, Echinoderm, &c., from the ovum to maturity, but the changes produced by age and habitat, are being carefully studied, with a view to a future and it is hoped a better system.

The investigation embraces a series of practical results, obtained through a large number of observations, having for their aim the difficult task of determining how far variation extends, in opposition to the theory, long used and still almost universally adopted at the present time, of the fixity of characters in species. In my paper "On the Variation of Sculpture in the Shells of the Genus Nassa," I pointed out the fact that, instead of shells being of necessity distinct species, because the external surface was either smooth, ribbed, or cancellated, such being stated to be the case in all

our conchological works, that there were several instances in which the whole of these variations were to be met with in shells of undoubtedly the same species; and very numerous are the examples of two or more of these supposed distinctive characters occuring in the same shell!

Since that paper was published, another and very important character, viz., the papillose ornamentation, has been traced into varieties of smooth forms. The *N. papillaris* is a papillose *N. glans*, Linn; and the *N. perlata*, Meusch, is the *N. gibbosula*, Linn. These appear startling assertions to persons who have only learned to distinguish the named shells of the books, the one from the other; but to the student of variation, such are necessary conclusions, following in the line of his study, compelling the shells to yield more and more of their hidden affinities. When we find the shells varying in form, in sculpture, and in every known character, or, at least, in every character used by the systematist in describing them, the first impression is that these are varieties of known species; but such is not the case. By uniting at least a dozen of the reputed species, you find that there is still no fixed or definite head to the group, consequently a more extended series is absolutely necessary until you reach a form beyond which the materials on hand will not carry you. Many of the shells intervening between two points apparently fixed, are so variable, that it is next to impossible to bring them within anything like definite limits; to such shells I would apply the term intermediates.

Intermediate Forms.

Fully nine-tenths of the shells now ranking as species will be found to come under this general term, and even many of those at present appearing as distinct will find a place in this series. Almost all the species in the genus *Cyllene* are simply varieties of one shell, and the *Pusionellæ* are

in the same state. If some of the drawers containing the species of *Succinea* were to be overturned, the shells would have to be redescribed, for neither the authors of the species, nor any other conchologist, could ever rearrange them in the same order again. It would be well if the spectacles of the learned author of *Cycladæ* could be placed with the species, for it is quite certain that without them no other conchologist will ever be able to recognise them. The *Ampullariæ* are in such an unsatisfactory state of arrangement, notwithstanding the generic sub-divisions, that the locality is of much more importance to the student than either the form or marking of the shell. The *Melaniæ* are in such a hopeless state of confusion that the species are only to be discovered by means of some supernatural agency; and the genus *Conus* has numerous genera within itself, a circumstance so remarkable, that it is impossible to say how such a curious phenomenon could have been brought about. Formerly, capital characters were obtained from the shells, so as to leave no doubt about the best mode of distinguishing them; but varieties, confound 'em, have crept in and spoiled all. The poor animals have been cut to pieces in every direction, to try and find something there, but the success has been about equal to the early trials; it has resulted in a complete failure; every supposed permanent character has turned out to be so variable that it cannot be trusted. Species-making was a good paying business, particularly to the men out exploring, and now genera-making is the order of the day, to suit the altered times. A beautiful variety was not to be thought of; it must be a distinct species, and the silly fellow who possesses it must boast of having the only one, no matter at what price.

By far the greater number of shells to which the term species has been erroneously employed, are simply intermediate varieties of variable species. Mr. Reeve makes a

very curious admission with regard to what he considers intermediate species; he says, "if we were to consider that because a species occurs between two others, it is a certain indication that the three constitute but a single species." If we admit this, a large number of our named species would become varieties. There are innumerable shells of every grade of variation, not only in the middle, but filling up every stage, and connecting at least half-a-dozen of the shells now bearing the title of species into one group, or, if the term is preferred, into one species.

The *N. costata*, A. Ad.; *N. labida*, Reeve; *N. micans*, A. Ad.; *N. multicostata*, A. Ad.; *N. cuvierii*, Payr.; *N. incrassata*, Mull.; *N. nodifera*, Powis; *N. crenulata*, Reeve (Brug?); *N. cremata*, Hinds; N. *reticosa*, A. Ad.; *N. gemmulata*, Lam.; *N. cumingii*, A. Ad.; *N. verrucosa*, A. Ad., not Gmel; *N. candens*, Hinds; *N. stigmaria*, A. Ad.; *N. marginulata*, Lam.; *N. crenellifera*, A. Ad.; *N. sequijorensis*. A. Ad.; *N. plicatella*, A. Ad.; *N. reticulata*, Linn.; *N. margaretifera*, Dunk.; *N. ravida*, A. Ad.; *N. variegata*, A. Ad.; *N. festiva*, Powis; *N. tritoniformis*, Kien; *N. acinosa*, Gould; *N. nivea*, A. Ad.; and *N. dentifera*, Powis; all belong to one and the same series, and are all intermediate varieties.

So far as my knowledge extends, not a particle of information on the subject of the external variation of sculpture is to be found in the works on conchology, either ancient or modern. If any number of men were to commence the study of a special branch of conchology at the same time (and they may be all equally eminent), at the end of their work it would be found that no two of them were alike in their conclusions; and if they were to write upon the same genus, each devoting a similar amount of time to the subject, the resources of each would be different; or if they all worked from the same collection

of objects, their opinions would differ with regard to some of them. One would examine his specimens critically, and take in every slight shade of difference that they might present; another would be satisfied with their general resemblances to the published figures, and make allowances for the slight variations; while a third, with a less critical eye, would be certain to commit errors, in fancied resemblances to figured specimens to which they might not be at all allied.

It is amusing to know *how* many of these very distinct species are made. Persons living in Australia, Madagascar, or various other localities, are requested by their acquaintances to collect and send them shells, to be submitted to the superior judgment of the home conchologist, who, of course, knows nothing about either their habits or the amount of variation to which they are liable. One set of varieties goes to America, and another to London, and we find two or three of the extreme variations described as distinct, whereas, if the necessary information had been forwarded by some intelligent naturalist, it would have been patent to everybody concerned that they were simply varieties of one variable shell. If *Helix nemoralis* were the inhabitant of some very distant land, at least a dozen very distinct species of it would appear in our books; they are very like troublesome weeds in a garden,—when once introduced, it is very difficult to eradicate them.

The *N. dentifera*, Powis, passes into the dark varieties of *N. paupercula*, Lam., the first from South America and the second from Australia.

Nassa delicata, A. Ad., *N. cuvierii*, Payr., *vide N. variabilis*, Phil., var. *costata*, Marr., and the small pale somewhat cancellated specimens of *N. paupercula* are very similar to some of the varieties of *N. cuvierii*, Payr.

N. nodifera, Powis, is intermediate between *N. coronata*, Linn., and *N. canaliculata*, Lam.

Another variety runs into *N. stolata*, Chem., and a curiously-coloured shell is so like the common European *N. reticulata*, Linn., that it is difficult to separate them.

The *N. thersites*, as figured by Quoy and Gaim, *Voy. de l'Artrolabe*, pl. xxxii., figs. 12–14, is an elongated variety of either *N. globosa*, Quoy, or *N. thersites*, Brug.

Another smooth form, with a thickened callous, connects it with the *N. cornicula*, Olivi.

N. compta, A. Ad., from Africa, is another variation of the *N. cornicula*.

Again, the cancellated callous shells of *N. thersites*, or *marginulata*, Lam., pass into the *N. pulla* and *arcularia*, Linn.

Strange as it may appear to the conchologists who have not studied this subject of variation, the *N. gibbosula*, Linn., is only a smooth form of the granular *N. perlata*, Meusch.

N. carmelii, Payr., is very closely related to, if it is not identical with, the *N. gaudiosa*, Hinds.

A small shell sent me a few days ago by G. H. Ponsonby, Esq., of London, was named by me some time ago, and is so like some of the small varieties of *N. trifasciata*, Gmel., that I am convinced these two forms merge into one at this point. *N. acuticostata*, Montr., is connected by means of some shells from Shark Bay, Australia, with the smoothly-ribbed varieties of *N. marginulata*, Lam.

The broad shells of *N. semigranosa*, Dunker, show such a close connection with similar-sized specimens of *N. pauperata*, Lam., both of which are semi-transparent, that I am quite satisfied to place them as varieties of one species.

The fossil *N. propinqua*, J. Sow., from the Crag, is a cancellated variety of the *N. semistriata*, Brocchi.

N. algida, Reeve, is easily traceable into the *N. canaliculata*, as figured in Reeve.

One of the most distinct shells, and one to which I could

at first see no alliance, has at length been brought into subjection, after a long struggle; it is a papillose variety of the *N. glans*, Linn. This discovery gives me the clue to a number of other varietal forms.

This subject of variation of sculpture is not a mere theory, but may be confirmed by easily observed facts.

Neither the subject of variation, nor its occurrence among shells of the same species, may be considered to belong exclusively to modern times. In 1776, Da Costa, in his *Elements of Conchology*, at page 12, distinctly refers to this subject. Macleay, Lamarck, and Swainson, each endeavoured to give systems to account for the variable nature of the materials, and to try to direct the attention of naturalists to the study of affinity as a means to an end.

The author of the *Vestiges of Creation* endeavoured to counteract the vast tide of species-making, by showing that the materials upon which the naturalist was building his fixed distinctions were derived from other allied forms, and must of a necessity be ever varying. Mr. Darwin has done more in this direction than all the men living, or that have lived or gone before him; and it is sincerely to be hoped that a better state of classification will result from a study of variation than we find in that based upon the fixity of species.

The costa has its origin just below the nucleolar whorls, and is always present, even in shells that are otherwise smooth and highly polished, or in hyaline or young and transparent specimens. These ribs are always started either from the upper whorls, or from the upper part of the whorl; generally they commence at a tubercle, and become elongated in such a way, that we find all the intermediate lengths from the simple tubercle, until the rib is extended to the base of the whorl, showing its complete development. On the contrary, the striæ or sulci are nearly always seen at the

base of the whorls, and appear to develop upwards; some of the shells having smooth ribs, are distinctly grooved in the interstices, while others have the sulci elongated, forming rings round the whorls, and intersecting the ribs at either regular or irregular intervals.

As many of these new and startling facts are becoming more apparent as our study progresses, and as many parts of this paper were written prior to some of these being developed, the summary must differ somewhat in its character from the deductions drawn from these early observations. Many of the species quoted as decidedly distinct have assumed a doubtful position, and nearly all of those quoted may have to take their places as varieties, instead of something very distinct. The *Nassa glans*, Linn., is very probably only a smooth variety of the *N. papillaris*, Linn.; the second, *N. perlata*, Meuschen, another papillose shell, is allied, and that very closely, with the smooth *N. gibbosula*, Linn.; the *N. arcularia*, Brug, once thought to be distinct, is now found to be an intermediate form, and can be traced through the *N. canaliculata*, Lam., as figured in Reeve, to the *N. lens*, Chem., a smooth form, that occurs without either costæ or coronation.

Here we have another instance of a shell varying through all the intermediate stages of external sculpture, from the smooth *N. lens*, Chem., to the *N. pulla*, Linn., in its finest state of cancellation, viz., the Red Sea variety. I have not the slightest hesitation in stating that it is my firm conviction, founded on the soundest possible basis, viz., that of well-observed facts, that all the shells of this genus start from smooth forms, and that all the variations between this and the cancellated shells are intermediate varieties.

Intermediate forms occur between each of the following pairs of shells:—

Between *Nassa papillosa*, Lin., and *seminodosa*, A. Ad.;

N. papillosa and *N. hirta*, Kien.; *N. reticulata*, Lin., and *cuvierii* Payr.; *N. canaliculata*, Lam., and *reticulata*, *N. margaritifera*, Dkr., and *canaliculata*; *N. canaliculata* and *thersites*, Brug.; *N. perlata*, Meusch., and *hispida*, A. Ad.; *N. nodifera*, Powis, and *costata*, A. Ad.; *N. nodifera* and *marginulata*; *N. thersites* and *decussata*, Kien.; *N. gibbosula*, Lin., and *bimaculosa*, A. Ad.; *N. bimaculosa* and *globosa*, Quoy and Gaim; *N. pulla*, Lin., and *leptospira*, A. Ad.; *N. leptospira* and *thersites*; *N. australis*, A. Ad., and *marginulata*; *N. nodifera* and *coronata*, Lin.; *N. coronata* and *kieneri*, Anton.; *N. mutabilis*, Lin., and *kieneri*; *N. arcularia*, Lin., and *marginulata*; *N. nodifera* and *stolatum*, Gmel.; *N. marginulata* and *cœlata*, A. Ad.; *N. marginulata* and *livescens*, Phil.; *N. marginulata* and *crenulata*, Brug.; *N. crenulata* and *sequijorensis*, A. Ad.; *N. crenulata* and *glabrata*, Marr.; *N. reticulata* and the fossil *reticosa*, J. Sow.; *N. arcularia* and *perlata*; *N. arcularia* and *canaliculata*; *N. glans*, Lin., and *rufula*, Reeve as per Kiener; *N. glans* and *hirta*: *N. glans* var. *suturalis*, Lam., and *gaudiosa*, Hinds; *N. gaudiosa* and *sertula*, A. Ad.; *N. cuvierii* and *incrassata*, Mull.; *N. glans* and *spirata*, A. Ad.; *N. spirata* and *mutabilis*; *N. mutabilis* and *nodifera*; *N. corniculum*, Olivi var., and *gaudiosa*; *N. picta*, Dunker, and *kieneri*; *N. canaliculata* and *crenulata*; *N. canaliculata* and *lens*, Chem.; *N. lens* and *modifera*; *N. tœnia*, Gmel., and *lens*; *N. coronata* and *lens*; *N. trifasciata*, Gmel., and *lens*; *N. trifasciata*, var. *unicolora*, Kien., banded, is a smooth *N. crenulata*, and there is also a smooth *N. sequijorensis* and *N. oblonga*, Marr., *N. marmorea*, A. Ad., and *mutabilis*; *N. costellifera*, A. Ad., and *reticulata*; *N. sordida*, A. Ad., and *hispida*; *N. hispida* and *gruneri*, Dkr.; *N. hispida* and *conoidale*, Desh.; *N. conoidale* and *marginulata*, Lam., not Reeve; *N. lentiginosa* and *punctata*, A. Ad.; *N. punctata* and *luctuosa*, A. Ad.; *N. punctata* and *velata*,

Gould; *N. albescens*, Dkr, and *sordida; N. mucronata*, A. Ad., and *rufula; N. marginulata* and *margaritifera; N. mucronata* and *monile*, Kien. var., Shark's Bay; *N. cremata*, Hinds, and *sequijorensis; N. fasciata*, Lam., and *festiva*, Powis; *N. monile* and *nodifera; N. hirta* and *mucronata; N. paupercula* and *mucronata; N. glabella*, Marr., and *elegans*, Kien.; *N. semigranosa*, Dunk., and *pauperata; N. regulare*, Kuster, and *incrassata; N. elegans*, Kien., and *graphitera*, Beck.; *N. caperata*, Phil., and *fasciata; N. bella*, Marr., and *incrassata; N. leptospira* and *corniculum; N. nodicincta* A. Ad., and *versicolor*, C. B. Ad.; *N. nodicincta* and *echinata*, A. Ad.; *N. capensis*, Krauss, and *serotina*, A. Ad.; *N. tinœa* and *canaliculata ; N. crassa*, Koch., and *sturmii*, Phil.; *N. gayi*, Kien, and *pauperata ; N. teretiuscula*, A. Ad., and *incrassata; N. lirella*, Beck, and *acuta*, Say.; *N. miga*, Adanson, and *incrassata; N. tritoniformis*, Kien., and *incrassata*; *N. decussata* and *polygonata* var.; *N. polygonata*, Lam., and *acuta*, Carp., not Say.; *N. variegata*, A. Ad., and *Keenii*, Marr.; *N. planacostata*, A. Ad., and *marginulata; N. plicatella*, A. Ad., and *reticulata ; N. plicatella* and *limata; N. bimaculata*, A. Ad., and *crassa*, Koch.; *N. arcularia*, Linn., and *marginulata*, Lam.; *N. leptospira*, A. Ad., and *planicostata*, A. Ad.; *N. semigranosa* and *Keenii; N. bimaculosa*, A. Ad., and *cuncellata*, A. Ad.; and between *N. plicosa*, Dkr., and *reticulata*.

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